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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CII.—No. 2638.] *LONDON: FRIDAY, JULY 21, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST..8d.

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T. MORRISON,
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14th July, 1916. E 659

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18th July, 1916. E 677

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on all types of electric cranes. Government controlled firm, Manchester district. State age, wages, and experience. No person already employed on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, mentioning this Journal and E 595.

Draughtsman Wanted, for

controlled Machine Tool Works in Scotland; first-class man with some experience in the designing of boring machines. State age, experience, and salary. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and E 639

Draughtsman Wanted, used

to factory lay-out; must be well up in civil and mechanical engineering; for a large Works in South Staffordshire. No person already employed on Government work will be engaged.—Apply, to your nearest LABOUR EXCHANGE, mentioning this Journal and E 674.

Draughtsman (Mechanical)

WANTED, to design (under supervision) small tools, &c. Splendid permanent opportunity for clever designer. Must be ineligible, residing within 10 miles, and not at present on War work.—Address, E 690, Offices of ENGINEERING.

Wanted, Tool Draughtsman,

systematic and capable of working out designs from rough sketches; some shop experience preferred. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2049. E 560

Junior Draughtsman Required

by London Engineering Works. No applicants not residing within a radius of ten miles, or already employed on Government work will be engaged. Address, stating age, experience, and salary required. E 657, Offices of ENGINEERING.

Wanted, for Controlled

works in Midlands, FOREMAN for engineering shop, good organiser, able control 20 to 30 men; must have practical mechanical and electrical experience in all kinds of repairs to machinery, gas engines, motors, and the manufacture of machinery in connection with constructional work, modern methods, jigs, &c. No one on Government work considered.—Apply, stating experience, age, and salary required, nearest LABOUR EXCHANGE, mentioning this Journal and E 574.

Wanted, Machine Tool Setter

for capstan and centre lathe department of controlled works in Manchester district. State age, wages required and experience. No person already employed on Government work will be engaged.—Apply to your nearest LABOUR EXCHANGE, mentioning this Journal and E 673.

Wanted, at Munition Factory

as Departmental Managers, energetic YOUNG MEN of good education who have been discharged from Army, or are ineligible. Must be capable of undertaking a full days work. Engineering experience an asset.—Address, E 588, Offices of ENGINEERING.

Engineering Pupil.—Vacancy

with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 4521, Offices of ENGINEERING.

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of ENGINEERING.

SITUATIONS WANTED.

Works Manager (General

Engineering) just over Military age is OPEN to ACCEPT ENGAGEMENT as above or similar responsible position. Thoroughly practical in all branches and well versed in office routine and cost systems. South or Midlands preferred.—Address, E 623, Offices of ENGINEERING.

Works Manager, Assistant

or Engineer.—Gent. (30), now manager of small controlled works, DESIRES CHANGE. Good organiser, expert repetition production of highest class mech. and elect. components, used to all classes of labour, good jig and tool designer, first-class technical and commercial man.—Address, E 699, Offices of ENGINEERING.

ROADS AND PAVING.

(*Concluded from page* 33.)

THE general conclusion that may be drawn from this study of the streets of various centres of population is, that the authorities, whether local or central, are impressed with the necessity of preserving well-constructed road surfaces for facilitating traffic, and are prepared to spend very considerable sums in providing the necessary improvements. This alacrity is traceable to several causes, prominent among which is the change in character and the greater demand made on street traffic. The introduction of mechanically propelled vehicles carrying heavy loads has shown the necessity for a rigid foundation under a repairable surface. The placing of electric wires required for tram service in underground conduits, and the general increase in substructure work, calling for frequent surface openings and repairs, has demonstrated the necessity of a new departure in road construction. The era of the stone block deposited directly on the ground surface has passed away, though there are not wanting instances to show that the stone block surface can be satisfactorily maintained on the original hard soil underlying it, where a street is not subject to frequent openings.

The feverish haste with which reconstruction has been carried on is not favourable to a selection of the best type of pavement. Improvements in various directions are noticeable, but it may be that it is not possible to combine all the desirable qualities of durability, freedom from noise, reduction of mud and dust nuisance, with small expenditure on upkeep, and some other considerations of lesser import. Experiment alone can determine the relative value of many practical suggestions, and such experiments require much time for their thorough investigation. For ten years and more experimental trials have been made on the Victoria Embankment, and though it has been possible to eliminate some of the less successful attempts of others, it is too soon to speak definitely. The Trinidad Lake asphalt laid on a binder course has proved very satisfactory under the traffic conditions that exist. Exclusive of tramcars, this traffic amounts on an average to over 10,000 vehicles a day, but it might prove needlessly extravagant to adopt so costly a pavement in districts where the wheel traffic is more normal. On some obvious grounds, a more practical result may follow from the Sidcup trial pavements, where a number of lengths of roadway, each of a different patent or specification, have been put down under uniform conditions, and submitted to approximately the same traffic. Some of these trial strips have been under observation for five years, and an interim report has been issued, but it is believed a final decision has not yet been made.

European road engineers have not developed any marked novelty in pavements. There has been little disposition to depart from the recognized types of surface coverings: rectangular stone blocks of various sizes, forms of macadam, wood block, and compressed rock asphalt. These are the favourite materials, and if we add the occasional use of various composition blocks and different types of bituminous macadam, ingenuity seems to be exhausted or to be confined to minor details. As an instance of the relative frequency with which these several materials are adopted, we may quote some statistics prepared by German authorities and necessarily a few years old, but which represented the proportions of different pavements with great accuracy at the time. The returns embrace seventy-six of the principal cities of the Empire, whose aggregate population exceeds 15 millions. These paved carriage-ways amount to a total area of 111 million square yards, distributed as follows:—

Stone block	... ...	60,000,000 sq. yds.
Macadam, Telford or gravel		35,000,000 ,, ,,
Asphalt	... ...	9,000,000 ,, ,,
Kleinpflaster	... ...	2,000,000 ,, ,,
Wood block	... ...	1,000,000 ,, ,,

Much of the remainder is slag; there is no reason to think that these proportions have varied much in the last few years.

Naturally, in the details of construction greater variation is shown. As already intimated, concrete foundations are regarded as indispensable when constructing new pavements in important thoroughfares, but great differences exist in the proper thickness for the foundation. Brussels, as we have seen, is content with 4-in. concrete, while London demands 12-in. in the central portions of the City. These are apparently the extremes; the standard thickness would lie about midway between the two. As in the thickness, so in the composition, great variation exists, showing that experiment is still in progress. An artificial Portland cement is contemplated in most specifications, but on streets of secondary importance the contractor is generally allowed to use a slag cement of inferior grades, and in some cases a lime mortar. Often the old macadam road material is used to furnish the aggregate for concrete, when a street is repaired with an impervious surface. The degree of finish given to the surface depends on the final covering. Where wood pavement is to be laid a smooth surface is necessary, the straight edge and hand smoothing being required, but for asphalt and granite block surface the same care is not exercised.

These variations in practice prevent any very reliable conclusions being drawn on the durability of surface, more especially as stone block pavement, which from its long use might have been accepted as a standard, has been gradually decreased in thickness with the employment of cement foundation. The stone block is the natural descendant of the old cobble stone, not entirely disappeared, that in primitive times was laid upon the ground as closely as possible, giving an unyielding surface, as uniform as the shape and nature of the material permitted. It was cheap, required little or no skill in laying, but possessed all the inconveniences of being noisy, rough, difficult to clean, and dusty. The cubical Belgian block, so common in the cities of Central Europe, marked an era of improvement. The surface was much smoother under wheel traffic, and the fairly uniform shape reduced the joints to less than an inch in width. Many varieties in size and character may be noted, depending on the local source from which the granite or porphyry is quarried. To-day the depth of the block has been reduced to a depth of 5 in. or 6 in., but this does not imply that the most useful or the most durable dimensions have been evolved, but rather that the principal stone-producing quarries insist on supplying that size for which there is the greatest demand. It is not unusual to shape the blocks by tool work with such accuracy that they can be laid with joints of less than ¼ in. in width, and in special cases even closer.

The "Kleinpflaster" of the Germans, of which small cubical stones form the main constituent, occupies an intermediate position between the stone block and a sheet asphalt surface. The "Durax" is a variation and an improvement on this, since gravel and tarred joints are regarded as essential components. Although in frequent use, the road authorities are not unanimous in its favour, few regarding it as a serious competitor with, or a satisfactory substitute for, the granite block. It is an advance on water-bound macadam, and a fair equivalent for a bituminous concrete. When laid as a carpet coat on macadam or on a cement foundation, the "Kleinpflaster" is well adapted for streets of light traffic. The low cost of maintenance and the absence from dust when constructed with tar-filled joints recommend it for suburban roads. The experimental lengths laid on the Sidcup road have proved satisfactory, but have not been in use sufficiently long to permit definite conclusions to be drawn. Birmingham regards it more favourably than does Liverpool, while Chelsea and Battersea disagree as to its value.

Tolerably easy access to the natural asphaltic rock, a limestone impregnated with bitumen, in Italy and Southern France, has led to the use of a prepared asphalt as a covering for the streets in many European cities. The rock is mined in rough fragments, run through a crusher and mill, reducing it to a fine powder, which, after being submitted to a high temperature, is spread on the road to a depth sufficient to give a final thickness of about 2 in. The pavement is so admirably adapted to many purposes that there is probably little truth in the tale that it was introduced into Paris to reduce the stock of material suitable for the building of barricades. Its main drawbacks are that in cold weather it is apt to be slippery, and in warm weather is liable to soften and roll. It is not suitable for steep gradients. It is easy to keep clean and is very free from dust, and would be in greater favour for light-traffic residential streets but for the high price. The figures that have been quoted show that the Germans hold this form of asphalt in high esteem. The Trinidad asphalt and some American varieties have been tried both in London and in Berlin with satisfactory results. The roadway of the Victoria Embankment can be regarded as a huge experiment for determining the pavement most suitable for heavy traffic, and here the Trinidad Lake asphalt has gradually displaced other competing materials; but longer and more varied trials are necessary to establish a decided superiority. The average cost appears to be about 9s. per sq. yard, including the cost of maintenance for five years, but exclusive of excavation.

Wood pavements have not maintained their first popularity, particularly those constructed of hard wood have proved disappointing under extensive traffic. The blocks wore unevenly and became rough and mis-shapen. For light traffic hard-wood blocks are still used, the practice being to dip these in tar and to lay them on a smooth concrete surface, finishing with a coating of tar. On the other hand, blocks of soft pine wood are extensively used, both in England and on the Continent, with great success. In use the blocks are treated with creosote oil, from 4 lbs. to 12 lbs. per cub. ft., and placed upon a perfectly smooth surface, moulded to the curve of the street. Rather wide joints are left between the blocks, into which tar is poured as a joint filler. When this has sufficiently hardened, the entire surface is gone over with a thin coating of liquid cement grout, to remove any stickiness due to the tar, and fine granite screenings or slag is spread over the finished surface to render it gritty, and provide a good foothold for horse traffic. The frequent gritting of the surface is a most important item, on which much of the success depends. Birmingham alone spreads annually about 3,500 tons of slag and crushed cement on wood pavements in order to avoid the inevitable slipperiness. When well constructed and well maintained, says Mr. Durham, "the wood pavement presents undoubtedly the finest street surface in existence; when the contrary is the case they are about as poor as any to be found." A frequent fault is insufficient impregnation with oil, permitting the blocks to rot and develop holes.

Mr. Durham's rapid *coup d'oeil* was sufficient to enable him to note the methods pursued in street openings, the blocking of the road from repairs, building operations, tramway construction, the erection of fire hydrants, as well as the plan of advertising street names and localities by night. The description of executive effort in these several directions adds to the interest of the professional and expert survey, but the account travels a little beyond the main inquiry into the various attempts to construct and preserve a durable and effective surface to public thoroughfares.

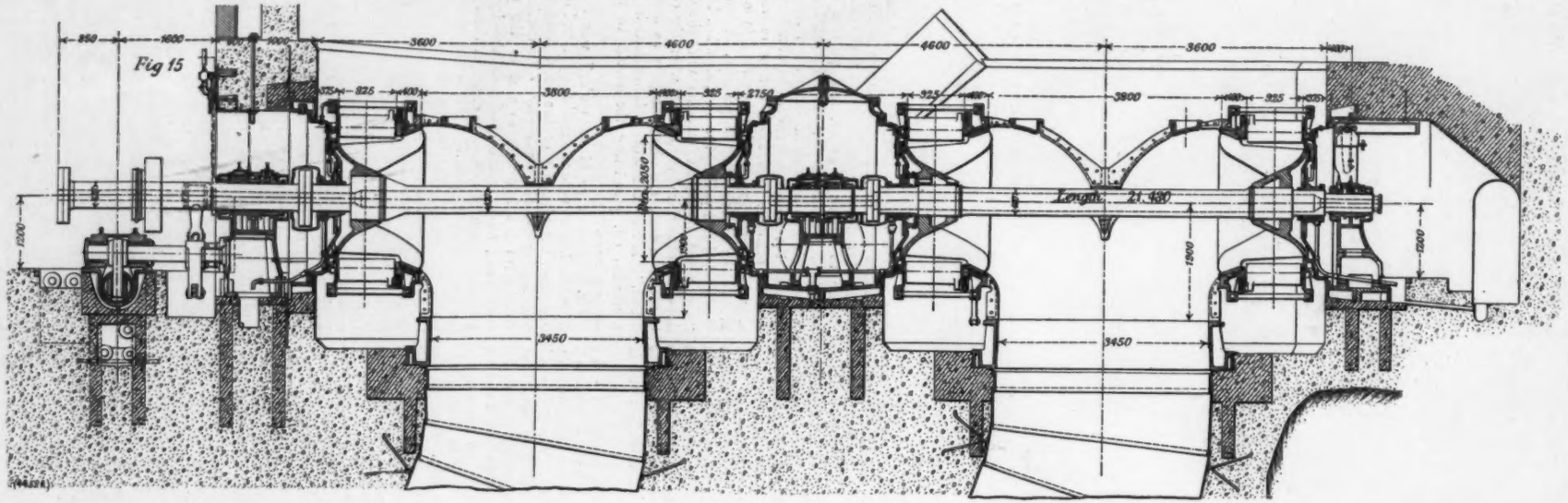
THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY.

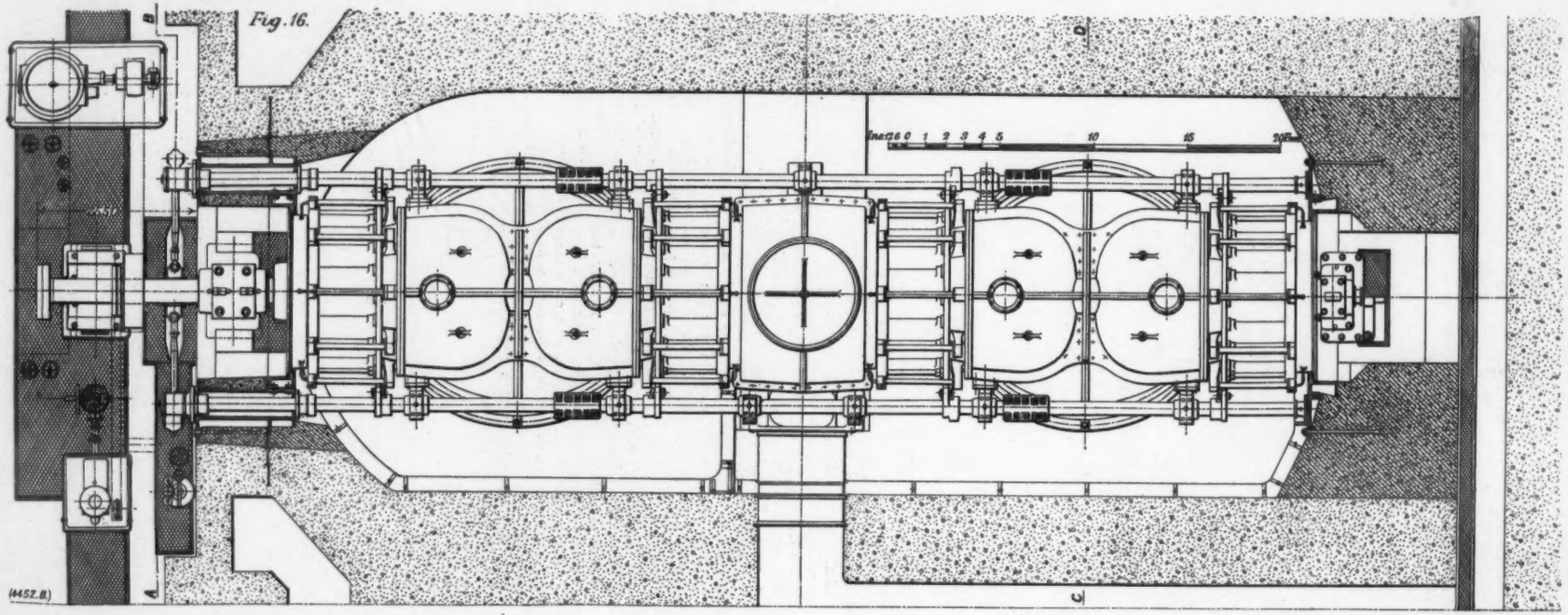
(*Continued from page* 32.)

HAVING dealt in the previous article with the collection and regulation of the water of the Odda River, we now come to deal with the power station in detail. The installation is so large that it is difficult to realise its magnitude from small-scale drawings, and it may perhaps be better grasped from the photographs on Plate V. The first shows the inlet canal. This canal is 52 ft. wide and 39 ft. deep, and through it the water flows in a solid body at a speed slightly exceeding 3 ft. a second. The inlet sluices can be seen at the end of the canal, while a nearer view of them is given in Fig. 22. Their great size is better realised from the view, Fig. 23, in which the hoisting gear is seen over the power station, this view being taken on the down-stream side. The five windows there seen are

THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY; THE 11,250-HORSE-POWER TURBINES.

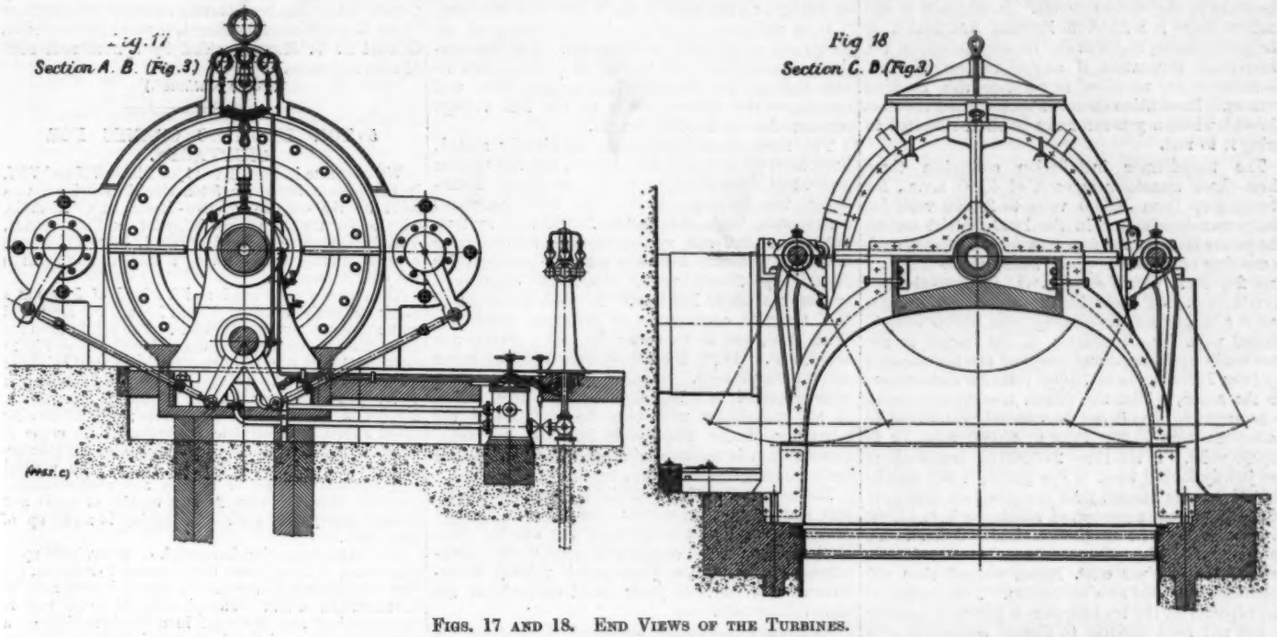
CONSTRUCTED BY THE KARLSTAD ENGINEERING COMPANY, KRISTINEHAMN, SWEDEN.





THE SWEDISH STATE POWER-STATION AT ALFKARLEBY; THE 11,250-H.P. TURBINES.

CONSTRUCTED BY THE KARLSTAD ENGINEERING COMPANY, KRISTINEHAMN, SWEDEN.



FIGS. 17 AND 18. END VIEWS OF THE TURBINES.

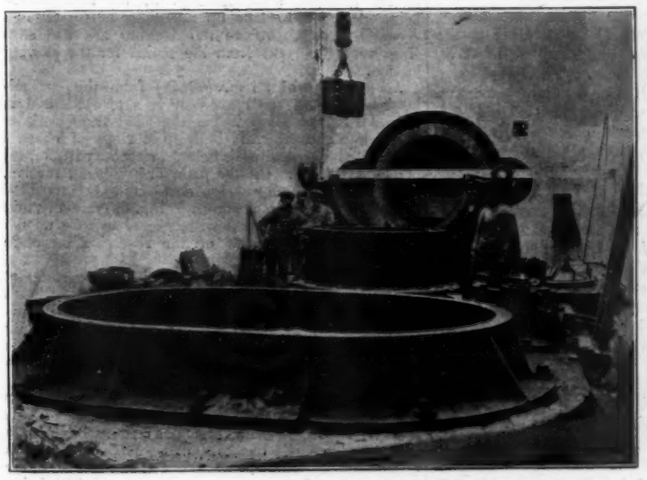


FIG. 19. TURBINE CASING.

FIG. 20. TURBINE BEARINGS.

the same windows which appear in the view of the generator room, Fig. 24.

The plant comprises five turbines, which stand on the bottom of the turbine chambers, each with four wheels and direct coupled to a generator in the machinery hall (see Plate III. in our issue of July 14). Each turbine (Figs. 15 and 16, on page 52) develops normally 11,250 horse-power at 150 revolutions per minute and with 15.6 m. (51 ft. 2 in.) height of fall. These turbines are amongst the largest so far manufactured. Fully loaded each turbine passes about 80 cub. m. (2,825 cub. ft.) of water per second. They are constructed as four-fold Francis turbines, with movable guide blades of cast steel, and are guaranteed to have an efficiency of 85.5 per cent. The wheels (Fig. 19, above) are of cast steel, with a diameter of 2,050 mm. (80 in.). The distances between the bearings (Fig. 15, page 52) are 9,200 mm. (30 ft. 2 in.) and 8,600 mm. (28 ft. 2 in.). The shafts are of nickel steel, from the Surahamman Works, with a largest diameter of 420 mm. (16½ in.) and bored 250 mm. (9⅞ in.). By this construction, bearings in the suction chamber are avoided. The load on the central bearing amounts to 22 tons; that on the forward bearing is 14 tons, and on the back bearing 8 tons. The shaft weighs 20 tons, and each running wheel 5.6 tons. The aggregate weight of the turbine is 190 tons; the suction tube casing (Fig. 19, above) weighs 30 tons, and the regulator, complete, 20 tons. The axial pressure is carried by the centre bearing (see Fig. 15). In addition, the running wheels of turbines Nos. 2 and 3 are fitted with hydraulically adjustable balancing gear. Two strong lay-shafts run along the sides of the turbine (see Figs. 17 and 18) and enter the machinery hall through stuffing-boxes. They are there direct-coupled to the servo-motor of the hydraulic regulator (Figs. 15 and 16, page 52). The turbines were manufactured at the Kristinehamn Works of the Karlstad Engineering Company.

The electrical machinery of the Alfkarleby power station generates three-phase current of 50 periods. Current of this periodicity has already for a considerable time been used by a majority of the works which are to receive energy from the Alfkarleby station, including the town of Gäfle, the works of Karskär, Forsbacka, Kloster, Herräng and Schebo, the towns of Västeras and Eskilstund &c. Each generator is coupled direct to the corresponding turbine. From the generators the three-phase current is transmitted through cables to the instrument house, situate about 100 m. distant from the power station, where it is stepped up and transmitted further by distribution lines, As at Trollhattan and Porjus, the control and the management of the entire electric installation is concentrated in a central switch-room in the instrument house.

The three-phase generators were supplied by the General Swedish Electric Company, Västeras. Each generator has been designed for 10,000–11,000 volts, and to give, with a rise of temperature not exceeding 45 deg. C., 10,000 k.v.a. with cos. $\phi = 0.8$, which corresponds with the normal output of the turbine of 11,250 horse-power. With a rise of temperature not exceeding 60 deg. the generators are guaranteed to yield continuously 12,250 k.v.a. with cos. $\phi = 0.75$, corresponding to the maximum output of 13,000 horse-power from the turbines. As a matter

of fact, the higher output is attained with a rise of temperature less than 45 deg.

Each generator is normally excited by means of a direct-coupled exciter. The voltage of the three-phase generators is regulated by hand by shunt-rheostats in the exciter circuit. In addition to the exciters there is a 220-volt lighting installation in the power house, and this can be used to excite the three-phase generators if any of the exciters fail. Resistances are provided to regulate this exciting current. In addition there is a special series rheostat through which a generator can be short-circuited to bring it to rest.

The transformer installation comprises three three-phase transformers, each of 4,500 k.v.a., for stepping-up from 10,000 volts to 20,000 volts for the power distribution in the local district around the power station, and four transformer groups, each consisting of three one-phase transformers (Figs. 27 and 28, Plate VI), of 4,800 k.v.a., for long-distance distribution. Of these latter transformer groups, one is arranged for stepping-up from 10,000 volts to 40,000 volts for distribution of the energy to the iron works to the north and east, and two for stepping up from 10,000 volts to 70,000 volts for distribution to the south, whilst the fourth transformer group is arranged so that it can be variously connected to transform from 10,000 volts to 40,000 volts, or to 70,000 volts. If the three 20,000-volt transformers are jointly looked upon as one group, it will appear that the power station thus comprises an aggregate of five transformer groups, of which one is of 13,500 k.v.a. and four of a maximum of 14,400 k.v.a. To each generator there thus corresponds a transformer group of 15–20 per cent. higher output than the generator can yield as a maximum. This margin in the capacity of the transformers is provided because it has not been possible to foresee accurately how the power consumption will be divided between the different systems. All the transformers have been supplied by the New United Electric Company, Ludwika, Sweden. They are constructed as water-cooled, oil-insulated enclosed transformers, fitted with expansion vessel and safety valve, maximum alarum thermometer and distance thermometer, besides alarum arrangements for notifying interruptions of the cooling-water circulation. Each transformer can mechanically stand short-circuiting on the high-voltage side with all the five generators of the power station coupled in parallel.

The local transformers have a secondary voltage of 20,000–22,000 volts, with 10,000–11,000 volts primary main voltage and cos. $\phi = 0.8$. They are delta-coupled on the primary side, and star-coupled on the secondary side. The test voltage is 20,000 volts for the primary and 50,000 volts on the secondary side during a quarter of an hour. At each end of each phase on the secondary winding, about 10 per cent. of the total number of windings are fitted with additional insulation. The permissible rise in temperature in the windings with 4,500 k.v.a. is 60 deg. above the temperature of the cooling water.

The one-phase transformers (Fig. 28, Plate VI) have a ratio of 10,500 to 42,500 volts with full load and cos. $\phi = 0.8$. They are on the primary side delta-coupled; on the secondary side they are delta-coupled for 40,000 volts and star-coupled for 70,000 volts. The testing voltages for the windings are 20,000 volts between the primary winding and the iron, and 150,000 volts between the secondary winding and the primary winding, during a quarter of an hour. The insulation in the secondary winding nearest the terminals is strengthened as in the 20,000-volt transformers. The rise of temperature in the windings, at 10,000–11,000 volts primary voltage and 4,000 k.v.a. (normal load) was specified not to exceed 60 deg. C., and with 11,000 volts and 4,800 k.v.a. not to exceed 70 deg. C.

As regards the use of electric energy in the power station the current for the auxiliary machines and for lighting is obtained from a central 220-volt continuous-current installation in the southern portion of the instrument house. It comprises two motor-generators, supplied by the same firm as supplied the transformers, each of 150 kw., with 220–500-volt continuous current voltage and 750 revolutions per minute, and an accumulator battery of 1,500 ampere-hours. This continuous current installation also supplies reserve current, as already explained, for the exciting of the three-phase generators. The motors of the motor generators are synchronous motors, which are worked with 380–420-volt three-phase current from two station transformers, each of 350 k.v.a., attached to the 10,000-volt bus-bars.

It is proposed to adopt electric heating of the ice-guards in the turbine chambers. For this purpose transformers will be installed which can be attached to the 10,000-volt bus-bars and will transform the current down to the low voltage requisite for the heating current.

The three-phase connections, as already stated, have been so arranged that four of the three-phase generators correspond each with its group of one-phase transformers, whilst the fifth generator corresponds with the entire 20,000-volt system. For the 10,000-volt system double bus-bars are arranged. Double bus-bars are also arranged for 70,000 and 20,000 volts, whilst the 40,000-volt system has single bus-bars. To each generator of Nos. I and II. corresponds an out-going 70,000-volt single line, and to generator No. III a 40,000-volt single line. From the 20,000-volt bus-bars seven single lines proceed. Space is reserved for a future installation of two 70,000-volt single lines, which in all probability will only be installed if the reliability of the 70,000-volt lines be less satisfactory than is anticipated; space is also reserved for an extra 40,000-volt line.

The zero points, both of the three-phase generators and of the transformers, are earthed through resistances, which greatly limit the current from earth faults. The 40,000-volt system is earth-connected through a three-phase voltage transformer with its zero point direct earthed on the high-voltage side.

As already mentioned, almost all the instruments and appliances are installed in the instrument house (Fig. 29, Plate VI). The conductors, transmitting the 10,000-volt current from the generators to the instrument house, are three-phase cables, of 3 by 240 mm., two for each generator. The house has a broad portion to the north, and a narrower portion to the south. The former contains the 40,000 and 70,000-volt transformers, corresponding with the generators Nos. I–IV, and all the appliances and apparatus for the 40,000 and 70,000-volt current. The same portion of the building also contains pumps and tanks for the cooling water and oil for transformers, and the heating installation, originally arranged for coal, but since supplemented by an electrically heated water-tank, intended normally to heat the whole of the instrument house, the former installation remaining as a reserve. A high-voltage laboratory is also located there, in which exhaustive tests of line insulators and high-voltage material used at the power station are made. This laboratory is fitted with a test transformer of about 100 k.v.a., from which test voltages up to 300,000 volts can be obtained. The test transformer is fed from one of the motor generators of the continuous-current installation. During the tests the motor generator is driven from the continuous-current side by current from the battery. High-voltage tests can therefore be undertaken at any time without risk of dangerous short-circuits and yet with a relatively high power behind them.

Accommodation has been reserved for excess voltage instruments. So far neither choking coils nor other excess voltage protection apparatus, beyond the earthing resistances, have been installed, on account of the considerable cost of such apparatus and their altogether questionable value. Although the power station has been working for several months, no fault whatever has manifested itself in any portion of the high-voltage installations, so that no need of excess-voltage protection—beyond earthing resistances and earth lines—has been found in practice.

The southern portion of the instrument house contains converters and battery, besides controlling boards, and in addition to the 20,000-volt transformers, the 10,000-volt instruments for the fifth generator and the entire 20,000-volt instruments. The switch-room is on the ground floor of this portion of the building; this room contains a main switchboard for the generators and the 40,000 and 70,000-volt systems and two other boards, respectively for the 20,000-volt system and the local installations. In this part are also commodious workshops and offices.

The design and construction of the Alfkarleby power station has been carried on under the auspices of the Royal Waterfalls Board, through its chairman, Colonel F. V. Hansen, aided by a numerous staff of able engineers.

(To be continued.)

5-TON ELECTRIC CRANES FOR SHIPYARDS.

WE illustrate in Figs. 1 to 11, on Plates VII and VIII, in the present issue, the 5-ton electric slewing-cranes built by the Officine Elettro-Meccaniche, Rivarolo, Ligure, for the N. Odero Shipyard, at Foce, Genoa. The photograph reproduced in Fig. 1, Plate VII, shows a series of these cranes serving a shipbuilding berth in the yard in question.

The cranes are designed to lift a load of 5 tons at a maximum radius of 35 m. (114 ft. 10 in.), and are tested with a load of 6 tons at that radius. The height from the ground-level to the centre of the crab-pulleys (see Fig. 2) is 34 m. (111 ft. 6 in.). Each crane has a total height of 43 m. (141 ft.). The lifting speed with a 5-ton load is 12 m. (39 ft. 4 in.) per minute; the load is traversed at a speed of 25 m. (82 ft.) per minute; and the slewing speed allows one complete revolution of the crane to be made in two minutes. The radius of the counterbalance arm is 17.5 m. (57 ft. 5 in.). The vertical and diagonal bracing of the jib and counterbalance arm are shown in Fig. 2, and consist of angle and channel bars; their horizontal bracing is made up of angle-bars.

The crane-supporting framework or tower, built up of angle-bars, is bolted down to a concrete foundation, the four legs forming at the base a square having sides of 6.8 m. (22 ft. 4 in.). The pivot of the crane post is hemispherical and is seated in a block resting on a ball-bearing, carried by the foundation-plate, as shown on an enlarged scale in Fig. 3, the arrangement being designed to take up the lower horizontal and vertical thrusts. Above the bearing are two slip-rings taking current from the mains for the slewing motion.

At a height of 28 m. (92 ft.) from the ground-level (see Fig. 2) the crane-post is supported, and is guided when slewing, inside the fixed framework or tower, by a race which is built up of rings of channel and angle bars, to which is bolted a circular path formed of a curved rail. On the path, or rail-head, revolve, when slewing, a series of eight cast-steel wheels mounted in couples on bogies, as shown in Fig. 5, Plate VII, and Fig. 8, Plate VIII. These wheels serve to take up the upper horizontal thrusts of the revolving structure against the fixed tower.

The crane is operated by continuous current at 240 volts. The switchboard is located in the driver's cabin, which is placed directly underneath the jib, as illustrated in Figs. 1 and 2. From the cabin the driver has the load in view in any position. The machinery is shown in Fig. 4 and Figs. 6 to 10. The hoisting motor is a 20-horse-power machine running at 400 revolutions; it operates the hoisting-drum by spur-wheel gearing. The hoisting-drum is grooved to receive the wire-rope. This is 20 mm. ($\frac{3}{4}$ in.) in diameter, and is made of best plough steel; it runs over two falls, and travels over wooden rollers placed 900 mm. (35 in.) apart, and located in the flooring of the jib and counterbalance arm. The hoisting-rope turns on the cast-iron pulleys of a four-wheel crab, which is built up of steel plates, and travels on a 0.690 m. (27 in.) gauge track, built of square bars. The load can be maintained at any height by means of a double-brake gear, the levers for which are located in the driver's cabin, one being electro-magnetic and the other a hand safety-brake.

The crab-traversing rope is of steel, 10 mm. ($\frac{3}{8}$ in.) in diameter, wound round a barrel 215 mm. ($8\frac{1}{2}$ in.) in diameter, near the end of the counterbalance-arm, and passing round a pulley at the end of the jib. The traversing barrel is operated through worm-gearing by a 4-horse-power motor running at 1450 revolutions per minute, the motor being located by the side of the lifting-drum, as shown in Fig. 4.

Slewing is effected by a 10-horse-power motor, running at 1310 revolutions, located as shown in Figs. 6, 8 and 9, on one side of the crane-post; its power is transmitted by worm and spur gearing (see Fig. 6) to a vertical shaft, this shaft carrying at its lower end a pinion which engages with a ring of internal gear mounted on the fixed tower as shown in Figs. 8 and 9. A suitable friction-clutch, protects the gear against any possible damage from shocks which might occur from a sudden stoppage of the slewing motion.

Each crane complete weighs 105 tons. The whole of the electrical and mechanical equipment was designed and built by the Officine Elettro-Meccaniche.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, writing on the state of the Labour Market in *The Board of Trade Labour Gazette*, says that on the whole the high level of employment of recent months was maintained in June. The war trades were still extremely active; in the others there were slight fluctuations, some showing an improvement and others a decline. The number of workpeople in industry was, of course, much less than a year ago, but those remaining were more fully employed.

The changes reported as taking effect in June, all of which were increases, affected over 930,000 workpeople, and resulted in a total increase of over 90,000*l.* per week. The principal bodies of workpeople affected were coal miners in Yorkshire, Lancashire and the Midlands, Wales, and Scotland, cotton spinners in Lancashire and adjoining counties, woollen and worsted operatives in certain districts of Yorkshire, iron and steel workers in the Midlands and South Wales, and building trade operatives in various districts.

The number of disputes beginning in June was 37, and the total number of workpeople involved in all disputes in progress was 33,823, as compared with 30,439 in the previous month, and 40,999 in June, 1915. The estimated total aggregate duration of all disputes during the month was 265,600 working days, as compared with 307,400 in May, 1916, and 176,600 in June, 1915.

The average weekly number of vacancies notified to all Labour Exchanges for the four weeks ended June 9 was 40,263, as compared with 37,717 in the previous four weeks, and with 35,303 in the four weeks ended June 11, 1915. The average weekly number of vacancies filled for the same periods was 31,785, 28,661, and 24,934 respectively.

Retail prices of food in the United Kingdom on the 1st inst. were higher than on June 1st by 1 per cent. As compared with July 1, 1915, retail food prices on the 1st inst. showed an average increase of 22 per cent. Taking the country as a whole and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in the retail prices of food since the beginning of the war may be put at 61 per cent., which is reduced to 55 per cent. if the increase in the duties on tea and sugar is deducted. The average increase in the cost of living of the working classes, taking food, rent, clothing, fuel and light and miscellaneous expenditure into consideration, between July, 1914, and the present time, is between 40 and 45 per cent.

A slight fall, 1.7 per cent., was registered in the general level of retail food prices in Berlin during May; as a result, the percentage rise since July, 1914, stood at 116 per cent.

A rise of over 4 per cent. in retail food prices in Vienna is recorded for May, the general level being thus brought up to 128 per cent. above that of July, 1914.

During April there was a decrease of 0.4 per cent. in the retail prices of food in Italy, and the general level fell slightly to a point 32.4 per cent. above that for July, 1914.

The seventeenth annual report of the General Federation of Trade Unions states that much is being said and much gratuitous advice given about the future of trade and industry. Stories are being circulated of Germany's preparedness for a commercial war waged as ruthlessly as the military operations of the past two years. Many million pounds worth of goods are, it is alleged, ready for dumping upon the shores of Britain the moment peace is declared. Apart from the improbability of a nation in the midst of its war travail making such preparations as are advertised, or of its seeking to rehabilitate its financial position by selling goods under cost price, there are a number of practical questions which require satisfactory answers. It is impossible for nations to sell unless they buy, and all the talk of capturing enemy trade is worthless until it is followed by internal reconstruction and educated effort. Any first attempt at commercial and industrial reconstruction in Great Britain, continues the report, might reasonably include the sweeping away from our commercial system and our schools of anything which involves unprofitable demands upon the child's mentality. People are constantly complaining of the inapplicability of educational results to the affairs of everyday life. In so far as the schools continue methods which unprofitably absorb valuable periods of the child's school life, and the nation bases its Civil Service examinations upon more or less obsolete formulæ complaints are justified, and overhauling and improvement should be insisted upon.

The same report adds that the Amalgamated Society of Engineers, on a small vote, and by an insignificant majority, have decided to secede from the Federation they were instrumental in forming in 1899. Accompanying the A.S.E. is the National House and Ship Painter's Society. The secession of these societies brings the federation's net membership below the million mark, and it weakens the general sense of solidarity which association for financial purpose always gives.

The income in the past year was 70,391*l.* 10*s.* 7*d.*, as compared with 70,845*l.* 5*s.* 8*d.* in the previous year. The total expenditure was 11,122*l.* 6*s.* 2*d.*, as against 23,986*l.* 5*s.* 6*d.* in the preceding twelve months, a decrease of 12,863*l.* 19*s.* 4*d.* The total amount carried to reserve, 59,269*l.* 4*s.* 5*d.*, exceeds that of any year since the inauguration of the federation. There are 146 societies affiliated with the federation, and the number of members paying contributions is 887,417, the total membership being 1,876,634. There were 176 disputes in the year, involving 15,510 workers, but when it is remembered that the average number of disputes for the five years preceding the war was 651, the loyalty with which trade unions have sought to avoid industrial trouble becomes strikingly apparent. The report concludes with a warm tribute to the late Lord Kitchener.

It is announced from Petrograd, says the *London and China Telegraph*, that the Commander-in-Chief has authorised the employment within the Minsk Government of Chinese and Koreans to work for private undertakings, provided the employers furnish them with the food and clothing to which they are accustomed. Both in France and Russia the shortage of labour through the war has led to the use of Chinese labour, against which there was such a tremendous outcry in this country when the experiment was made in South Africa. At a time of crisis like the present there seems no valid reason why the Allies should not avail themselves of the plentiful supply of Chinese coolies, who, if employed under proper conditions, make excellent labourers for certain classes of work.

The Pennsylvania Railroad System announce that they will have at least 50,000 men, perhaps as many as 60,000, on the lines east of Pittsburg, pledged and ready for special duty to prevent, if possible, a complete interruption of the service in the event of a strike. The freedom with which volunteers have come forward does not mean that a strike of 25,000 drivers, stokers, guards and trainmen could fail to be a serious matter or that the railway could be kept in operation except with great difficulty. The volunteers would have to be withdrawn from all branches of the service, and in some cases would require additional training for their new duty. It, however, proves that the railroad can count upon the complete loyalty and devotion of a very large number of employees in an emergency. Some of the drivers, stokers, guards and trainmen have, further, assured their chiefs that they would remain loyal. Among the clerical staff response has been very general. The overwhelming majority of the men at the shops have placed their services at the disposal of the company. Many pensioned employees have eagerly written that they are still fit for active work and ready to serve at call. One effect of the call for volunteers has been to increase very greatly the number of new applications for positions in the service.

A dispute which had arisen among the Manchester Ship Canal dockers has been temporarily settled pending the award of the arbitrator. The men's demand is for an increase in wages of a penny per hour, in addition to the 2d. per hour, war allowance, which had already been granted them. The arbitrator is Mr. P. W. Atkin, the Stipendiary Magistrate for Salford.

Sir Richard Cooper, M.P., says the *Birmingham Daily Post*, addressed a largely attended meeting of trade-union delegates, held under the auspices of the local Trades and Labour Council at Walsall, on Thursday, the 13th inst. Sir Richard dealt with the possibility of a closer relationship between Capital and Labour, and urged that misunderstandings which had existed in the past were capable of being removed, and a new system introduced which would be mutually advantageous to both employers and workpeople. He said the question was to be considered at a conference in Birmingham in the near future, and the point he wished to put before organised labour was whether, if they found a certain number of employers willing to give them much of what they had been fighting for—recognition and a better wage system—they were prepared to respond, and to bring any class of labour which was at present inefficient up to a higher standard. It must be clearly recognised that if a much higher rate of wages was to be paid labour must be brought up to a corresponding degree of efficiency. He instanced the railway system as an industry which offered special scope for paying better wages and reducing rates. He was assured that in present circumstances a railway locomotive was used only eight days out of 100 in actually hauling goods. There was a great outcry about the shortage of trucks, but experienced railwaymen assured him the companies had really hundreds of thousands too many. That being so, he considered the position ridiculous. With the comparative close proximity of all our manufacturing towns to the great ports, our rates of carriage ought to be lower than in other countries where they had not the advantage of short haulage, but as a matter of fact other countries not only had lower rates, but paid double the amount in wages.

Inefficiency was not all on the part of the employers, as was shown by the statement that women who had gone into munition factories absolutely unskilled could in a few weeks turn out double the finished product of some skilled trade-unionists. He did not suggest that that applied to trade-unionists as a whole, but he believed it was a fact that a large proportion of labour in this country was not as efficient as it might be. He had works in America—where, he admitted, there was more speeding-up of labour, but where for the same hours of work double the rate of wages was paid—at which skilled engineers could turn out machines and land them in this country as cheaply as a Birmingham or Sheffield manufacturer could do. This fact, he thought, showed that with a proper system of organisation in this country wages could be doubled.

Mr. Arthur Henderson took the chair at the meeting with the organised trades held on Tuesday last at Caxton Hall, to consider the question of postponed holidays. He opened the meeting by stating that the Government were fully aware of the sacrifices they were asking of the men and that these sacrifices were only demanded because of the imperative necessities of the moment. He drew attention in this connection to the two following striking characteristics of the great offensive: first, the unlimited expenditure on munitions of all character which alone makes successes possible, and, second, the very small proportion of deaths and serious wounds as compared with the much larger proportion of slighter wounds. This, in his view, was definitely due to the superiority over the enemy's artillery achieved by the guns and munitions which had been produced in such considerable numbers by the munition workers in the country.

Mr. Montagu emphasised what Mr. Henderson had stated as to the Government's recognition of the sacrifice demanded of the workers and of the loyal, untiring services which they had given and which had already produced such brilliant fruits. To show the vital importance attached to the undiminished and constant supply of munitions, he read a letter, dated July 13, from Sir Douglas Haig, which conveyed a message to munition workers and people of the country. The letter stated that the troops in France fully appreciated the strenuous and self-sacrificing efforts which were being made by their fellow-countrymen at home to furnish them with the quantity of ammunition necessary to bring the campaign to an early and successful conclusion. The munition workers at home, Sir Douglas added, very generously gave up their Whitsuntide holiday and were promised two days in August instead. He fully appreciated how tired they must be and how much they must be looking forward to that promised holiday. Yet he felt confident that if they could but see their comrades fighting, both night and day, with heroism and determination which were beyond all praise, they would not hesitate to surrender those two days' rest, and would devote them to maintaining and if possible increasing the supply of guns and shells, without which victory was impossible. He asked that the facts be put before the workmen and he knew they would consent.

Dr. Macnamara emphasised the immediate connection between the industrial army at home and the army in the field. The soldiers in the workshops were now more truly than ever handing to the soldiers in the field the weapons which alone could give success. The sacrifice which was being asked of the workers at home was a considerable one, but it could not be weighed in the balance against the sacrifice which was being hourly demanded from the soldiers in the field. Dr. Macnamara had every confidence that the appeal would not fall on deaf ears.

After discussion, the following message in reply to Sir Douglas Haig's letter was unanimously accepted with acclamation, after speeches in support of it had been made by Mr. J. R. Clynes, M.P., Mr. Dawtry, Mr. Ben Tillett, Mr. Baker, Miss Varley, and Mr. John Hill:—

"To General Sir Douglas Haig.

"This meeting of representatives of organised trades, including both men and women engaged on munitions work and in other occupations, assure you, and through you the British Army, that we will not relax our efforts to maintain and increase the supply of ammunition, guns, and other war material which is necessary to enable you and the Army to bring to a victorious

SEWAGE PURIFICATION PLANT AT PONT-Y-WAL SANATORIUM, TALGARTH, BRECON.

CONSTRUCTED BY MESSRS. TUKE AND BELL, LIMITED, ENGINEERS, LONDON.

Fig. 1.

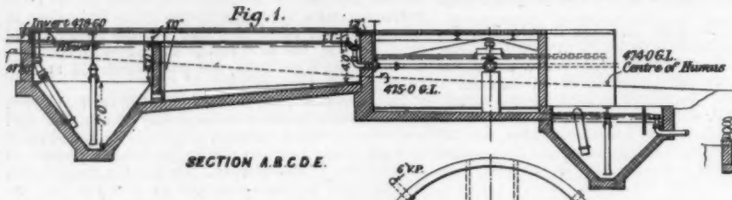


Fig. 3.

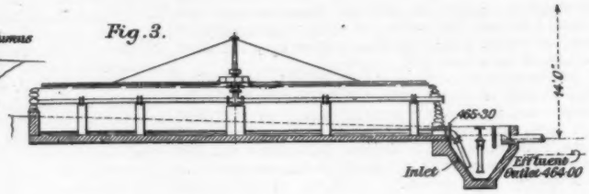


Fig. 2.

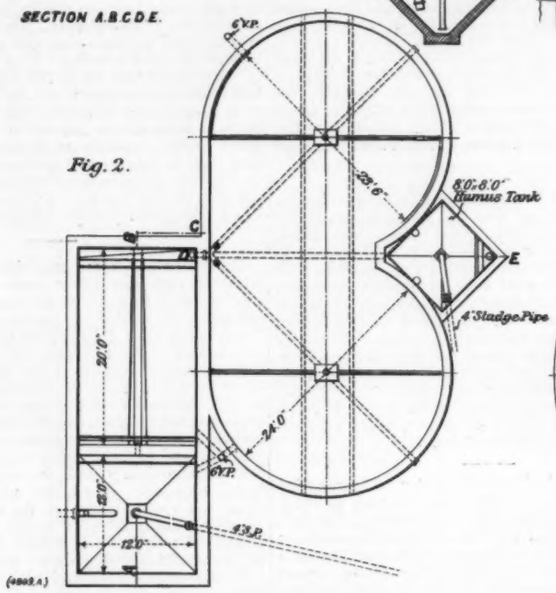
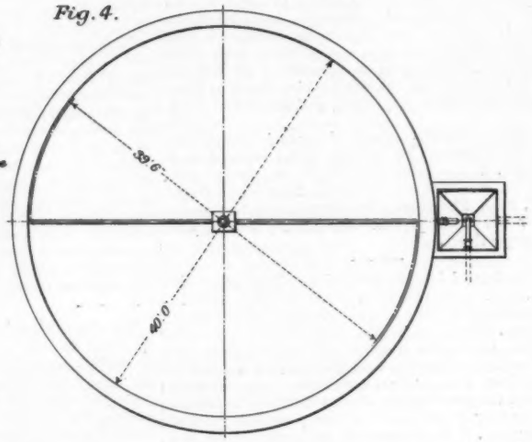


Fig. 4.



conclusion the great task which you have so gallantly and successfully begun.

"For this purpose we have resolved to recommend the postponement of all holidays, general and local, which involve interruption of production until such time as we are assured by you that military exigencies permit of the postponed holidays being taken.

"(Signed) Arthur Henderson (Chairman)."

It was subsequently arranged that a small committee elected by the Conference should meet the Committee under the chairmanship of Mr. Henderson, which is dealing with the general question, to discuss outstanding details. The meeting terminated with a vote of thanks to Mr. Henderson and the singing of the National Anthem.

SEWAGE PURIFICATION PLANT AT PONT-Y-WAL, BRECONSHIRE.

We illustrate on this page and on page 60 a sewage purification plant recently completed by Messrs. Tuke and Bell, Limited, of the Carlton Engineering Works, High-road, Tottenham, for the sanatorium recently erected at Pont-y-Wal, Talgarth, near Brecon, by the Welsh National Memorial Association.

The scheme was selected, out of several alternative proposals, by Messrs. E. T. Hall, F.R.I.B.A., and H. H. Humphreys, M.Inst.C.E., acting respectively as architect and engineer to the above association. It was devised to deal with the drainage from 400 persons, the estimated volume of flow being 16,000 gallons per diem. The contour of the ground gave a fall of about 12 ft., which made it easy to provide both a primary and a secondary bacterial filter, through which the sewage is passed in succession. A high degree of purification is thus effected, which is important, as the final effluent flows direct from the humus chamber into a neighbouring stream. Before being passed on to these filters, however, the sewage is submitted to a preliminary treatment in a septic tank or liquefaction chamber. This appears on the left in Fig. 1, and, as shown in the general plan, Fig. 2, is a rectangular chamber. Fig. 1 is a bastard cross-section through this general plan and shows the lay-out of this chamber. It is divided, it will be seen, into two portions. The first has a conical bottom, and acts as a sludge sedimentation tank. The incoming drain is 9 in. in diameter and is carried down to a point near the bottom of the chamber. The effluent passes, as indicated, to the second part of the chamber, over a weir, fitted with a scum-board. An automatic sludge outlet pipe and valve are fitted to the first portion of the chamber. The sewage finally leaves this liquefaction tank by passing over a second weir, also fitted with a scum-board.

This tank effluent passes next to the primary aerobic filters, which, as indicated in Figs. 1 and 2, and Fig. 5, page 60, lie immediately adjacent to the liquefaction tank. Each of these filters is 24 ft. in diameter. They are built up in brickwork and are completely covered over and are fitted with ventilators. There is thus no nuisance from smell arising from the distribution of the tank effluent. This is sprayed over the bed by revolving sprinklers, each 23 ft. 6 in. in diameter. The rotation of these is "positive" in character, being effected by the weight of the fluid, and not by the reaction of escaping jets. A ratchet wheel is fixed below the revolving distributor, and concentric with it. The effluent is delivered from the tank into one or other of two tipping buckets. As a bucket fills it tips, and in doing so moves the distributor round by a system of levers and pawls engaging with the ratchet wheel already mentioned. In this way rotation and a consequent fair distribution of the effluent is secured, no matter what the variation in the rate of supply. With a full supply the rotation of the arms is practically continuous. When the bucket tips, its contents flow along the arms of the distributor. These are not pipes, but open channels. The upper edge of each side of these channels is serrated, and the effluent escapes through these serrations, which are not liable to be choked, as small holes in a pipe would be.

From these primary beds the effluent flows to a first humus chamber, Fig. 1, which is fitted with a dip inlet and a weir outlet. It has a conical bottom, and is provided with an automatic sludge outlet pipe and valve. On leaving this chamber the effluent passes on to the finishing filter shown in Figs. 3 and 4 and in Fig. 6, page 60. This is 40 ft. in diameter, and is placed near a natural stream, and about 156 ft. distant from the primary beds.

It is, as appears from Fig. 6, built up in the open, being constituted of large pieces of clinker resting on a concrete base and kept in place by low retaining walls; the same system of distribution from revolving arms, in this case 39 ft. 6 in. long, is used here as in the case of the primary filters. On its way from this finishing bed to the adjacent stream the effluent passes through a second humus chamber similar to that already described.

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the correspondence in ENGINEERING dated the 30th ult. and 7th inst., if Mr. Ellson's letter, on page 21 of your issue of the 7th inst., at all represents the best that employers have to say with regard to the remarks of "Staffed," it must be very satisfactory to the latter gentleman. In place of any argument there is a list of unwarrantable assumptions, viz., that:—

1. "Staffed" is not a representative of draughtsmen as a class.
2. He is incapable of holding his own.
3. That he can join a trade union that does not exist.
4. That his salary and the value of his services are incompatible.
5. That his services can be dispensed with.
6. That if he has approached his employers, he did it in an improper manner.
7. That he does not possess either self-reliance or self-confidence.
8. That "Staffed" is in a highly reprehensible frame of mind.

Mr. Ellson's penultimate paragraph is incomprehensible and involved, but certainly does not seem to further what arguments he wishes to bring. Both parties to this correspondence are absolute strangers to the present writer.

Yours truly,
"FAIR PLAY."

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to your correspondent "Efficiency," in your last issue, may I be allowed to point out to him the existence, in the very town from which he addresses his letter, of an association of engineering and shipbuilding draughtsmen, which has since two years been trying to remedy the very wrongs he has been writing about, and about which also your correspondent "X. Y." made his remarks. The association in question is called "The Association of Engineering and Shipbuilding Draughtsmen," its secretary being Mr. L. Blair, 94, Hope-street, Glasgow. This society has very high-minded aims, has branches in the Merseyside and Newcastle districts, and well merits all the support it can get from draughtsmen and other engineering staff men all over the country for the aims and good work it has already done and intends doing in the future for draughtsmen.

A card to the secretary above-named will no doubt bring you much of interest to the profession at large.

I am, Sir, yours sincerely,
ENGINEER.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the replies to my letter of the 7th inst., and would like to point out that

all of your correspondents appear to have lost sight of the original complaints by "Staffed."

The remarks I objected to, and on which I based my reply, were :—

1. That *at the commencement of the war* salary was reduced.

2. Wages were increased two, three and four times, solely by the help of the Trade Unions.

3. The employers had draughtsmen by "the back of the neck."

I will again deal with the above and, if possible, make my views more clear.

1. I hold that at the commencement of the war, which is the period at which "Staffed" had his salary reduced, there were unlimited opportunities of obtaining situations and that no restriction was put on the movements of draughtsmen for at least 12 months from that time. I made no mention whatever of present conditions, which, I am perfectly aware, are entirely different. I probably have as good a knowledge of the Regulations as your correspondent on this point.

2. Through a printer's error my reply to this did not convey my meaning. If, for "Skilled men before the war *were*" is read "Men, skilled artisans long before the commencement of the war, *are at the present time*," the reply will appear differently. I had intended having this sentence corrected, but delayed until too late.

3. With regard to the third point, I still say that it is not the employers' intention to have us "by the back of the neck." If this phrase *can* be applied at this present time, it must be at the hands of the Government; but surely when it is remembered that we all hold our positions now for the good of the country, and that the alternative is military service, with its infinitely greater inconveniences and risks, no one will feel justified in applying it.

Now, in reply to the letters this week, I am quite aware that reliance and confidence are not necessarily accompanied by ability, but I do hold that ability gives, or at least tends to give, those qualities.

Neither do I profess to be "the missing link;" rather I consider there is no profession giving greater opportunities, nor one in which the knowledge of our lack of knowledge becomes more evident the further we advance, than in engineering; and, I might add, for the benefit of your correspondent, that I have been learning this in the various works and offices for the past 16 years; so that, although not a veteran, neither am I a novice at the work, as is suggested.

I do not remember a statement of mine objecting to combination; in fact, I inquired at the same time that my reply to "Staffed" was posted, for full particulars of an Association I saw mentioned in the same number of ENGINEERING, but for some reason have not yet received a reply.

I was led to do this by seeing that all offices in connection with the Association were honorary, and I hold that much better results are likely to accrue to members of any association—with similar objects in view—having dealings with employers, when any discussions are conducted in a friendly way and on a sound and—note this—reasonable basis.

This position is much more likely to be attained by an Association with honorary officials, having no "axe to grind" beyond the general advancement of the profession than by the paid agitators of Trade Unions, who depend for their salary on their position, and who must make something to do, whether for the general good or not, in order to keep their job.

I fully agree with your correspondents that any body working on these lines would be of mutual advantage both to employers and employed, but would not have for its object the bolstering up of salaries in order that members might be able to say they obtained them "solely by the help of the Trade Unions."

Apologising for taking so much of your valuable space,

I remain, &c.,

Rugby, July 17, 1916. H. S. ELLSON.

TO THE EDITOR OF ENGINEERING.

SIR,—It is rather surprising to find at this period, when the average draughtsman is exercising his mind with the economic problems which loom so largely before us, that there still exist a few, such as Mr. H. S. Ellson, who persist in clinging to ancient fetishes, despite all warnings to organise and prepare for the coming industrial struggle. It is only now as an organised nation that we are putting up a successful fight against the most scientifically organised nation in the world. A grimmer struggle is before us, for which we are totally unprepared, and more than individual effort is required if we hope to win through. Such a staple industry as engineering will require the interest of the Government, and only by skilful organisation can we hope to maintain its supremacy. Old, haphazard methods must go. Daily, our economists are pointing to the need for men of high practical and scientific training in the fields of engineering. That need must be met by the fostering care of the Government, but more is essential; draughtsmen as a community must render assistance and see that the status of the profession is improved by every means in their power. This can only be achieved by draughtsmen organising.

Organisation does not resolve itself merely to a question of providing a means of curtailing the misguided acquisitiveness of some employer, nor does it mean inculcating an aggressive attitude towards officials. There are matters within the precincts of the profession which can only be gauged in true perspective by means of an organisation. It is by the influx of knowledge to a central body that information regarding the trend of affairs in all districts may be disseminated and so render draughtsmen aware of the limitations and possibilities of the profession. The knowledge of where one's labour may meet with amenable conditions is surely an asset; and it is just as desirable that publicity be given to the tactics of employers, when these are a menace to the profession, and might jeopardise the career of some unwary individual.

As a member of the General Council of the Association of Engineering and Shipbuilding Draughtsmen, I can give my experience in pertinent matters with some assurance. I have no desire to reiterate all the grievances with which draughtsmen are at present afflicted, and to which publicity has already been given in your valuable paper; but I would like to point out that it is hopeless for the individual to cope with the restrictions which are daily brought to the notice of the Association. Never has there been such a strong feeling among draughtsmen throughout the country as to the necessity for organisation. The demand for an association to safeguard the interests of the individual and promulgate the general welfare is creating a steady influx to our ranks. Had we been strongly established at the beginning of the war, draughtsmen would not now be suffering from all the restraining influences of the Munitions Act, and reduced to their present position. As a young organisation we had no voice at the psychological moment, and so draughtsmen now reap the results of their past years of lethargy and indifference to economic matters. A valuable lesson, however, has been learned in that it has brought home to the majority of draughtsmen the necessity of being strongly organised.

We must prepare to face the industrial turmoil that will follow in the wake of the trade war. We can no longer permit the profession to be left "to the interplay of purely individualistic factors—selfishness, more or less 'enlightened;' capricious sentiment; and our old friends supply and demand."

All the efforts of the Association of Engineering and Shipbuilding Draughtsmen are at present employed in augmenting the membership; and, if the present rate of progress is maintained, it should not be long ere we have the support of the majority of draughtsmen in the United Kingdom. While we are striving to gain a membership sufficient to bring strong concerted action to bear against all matters that would impugn the general welfare, we have in mind other schemes which should prove beneficial to the profession. We look to the future to bring into being means of conserving the profession to qualified men. We trust to provide benevolent schemes, and the question of dealing with insurance for sick and idle benefits is one that occupies our minds. We have created means of social intercourse among the draughtsmen in various centres, and we trust to have this social feeling permeating through all grades of the profession. A literary medium is published periodically, dealing with economic matters, and giving scope for the literary or artistic abilities of draughtsmen.

The aims and objects of the Association commend themselves to every intelligent draughtsman, as we provide the nucleus of a scheme which should encourage the higher ideals and tend to substantiate our commercial aspirations.

It is the duty of every draughtsman who has his own interests and the welfare of his profession at heart to join the Association now. *Vires acquirit eundo.*

Our secretary, Mr. Louis Blair, 94, Hope Street, Glasgow, will be pleased to answer all communications regarding the Association of Engineering and Shipbuilding Draughtsmen.

Yours truly,

T SQUARE.

THE "EMPRESS-STORSTAD" COLLISION CASE.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of April 28, which has just reached me here, there appears on page 48 an abstract of remarks by Mr. Hillhouse* in the discussion of my paper on the "Empress-Storstad Collision Case," read before the Spring meeting of the Institution of Naval Architects. Unfortunately, absence in America prevented me from attending these meetings, and my reply to the discussion was only mailed to London a few days ago. As this will not appear in your columns, and as Mr. Hillhouse's remarks are calculated to create a false impression, which I do not care to pass, as it were by default, in your widely circulated journal, I should be glad if you will allow me to deal with the same through your correspondence columns.

Mr. Hillhouse characterises my theory of what occurred between the Storstad and the Empress as "very fantastic and unnecessarily complicated." The curious thing is that Mr. Hillhouse did not hesitate, when it suited him, to use my theory and my model of the Storstad's damage in his own work at Quebec. The fact that from the very same data, read possibly with unconscious bias in favour of the Empress or the Storstad, as the case may be, we arrived at very different conclusions, need not surprise one. There is this to be said, however, that while my theory, as Mr. Hillhouse calls it, was evolved from a most exhaustive study of the Storstad's damage, Mr. Hillhouse was never even on board that vessel. He not unnaturally, therefore, entirely misread the indications on my small-scale model of the Storstad damage, which he also used to determine his point of contact, angle of contact, and the depth and fore and aft extent of the wound in the side of the Empress.

It may be stated that as regards the point of first contact the Court in its report absolutely confirmed my views. In regard to the angle of contact, Mr. Hillhouse found this to be approximately 80 deg., as against my figure of 40 deg. The following extract from Mr. Hillhouse's evidence in cross-examination at Quebec will show whether his computations are entitled to discredit mine :—

"*Q.* From that, assuming the draught of the two vessels as now known, Mr. Reid has figured that the angle is in the neighbourhood of 40 deg. Now do you feel that your study of the Storstad has been sufficiently accurate to justify you in differing so radically with him, or is your estimate largely approximate ?—*A.* My estimate was largely taken, partly approximated, by looking at the Storstad, and partly from this model. I measured the point on each side to which the damage extended and, joining these up, I got an angle of approximately 80 deg."

"*Q.* Well if, as a matter of fact, the damage on the upper deck was due first to penetration, and subsequently to leverage and a swinging motion, that would not be a very accurate factor to work from, would it ?—*A.* No; it is only accurate if that damage indicates the extent on the two sides to which penetration has taken place."

"*Q.* If the vessel comes in on an angle of 40 deg., and then is swung by virtue of a forward movement of the Empress after the upper deck of the Storstad is under one of your decks, she is wiped right off—everything on the upper deck is wiped off as the vessels swing ?—*A.* Probably." In other words, Mr. Hillhouse, using my model, measured the angle of impact by a method which, as I have shown in my paper, could only result in error.

Mr. Hillhouse's idea of the extent of the penetration of the Empress by the Storstad was 18 ft. This means that not only would the longitudinal bunker bulkheads in the neighbourhood of the point of contact, established by my investigation and agreed to by the Court, be destroyed, but a boiler at this point would have been knocked off its stools. Extracting again from Mr. Hillhouse's cross-examination :—

"*Q.* As I have listened to the testimony I have understood that men in the boiler-room saw water coming out of the bunkers and that the inside wall of the bunker was not at all ruptured. Is that your understanding of the facts ?—*A.* My understanding is that the water only came through the bunkers' doors. *Q.* And that the inner side of the bunker was absolutely untouched by the stem ?—*A.* Yes."

In other words, the depth of penetration measured at right angles from the Empress's side could not exceed 14 ft., the distance in from the vessel's side of the longitudinal bunker wall. I have found for 12 ft. from the Storstad's damage.

Now we come to the question of whether the Empress was stationary or in motion at the moment of collision. Mr. Hillhouse has a theory to account for the extraordinary swing of the loaded Storstad through an angle of 100 deg. before the two vessels parted, as testified to by eye-witnesses. It is given in his evidence :—

"*Q.* Assuming that to be the case, Mr. Hillhouse, the fact being admitted that after the Storstad entered the side of the Empress, the Storstad was seen disappearing in the fog astern, or was apparently swung to starboard herself, to what do you attribute such movement of the two vessels ?—*A.* Well, that might have been caused by the Storstad going astern with her rudder over; it might have been caused by a head motion on the Empress."

In its Report, the Court states :—"Captain Kendall said that at the time of the collision his ship was lying in the water stopped dead, and that therefore no movement of his ship contributed to the force of the impact. This is perhaps doubtful. We think that although his engines had been reversed for some minutes, Captain Kendall may be mistaken in supposing that way had been entirely taken off his ship, and it is possible, therefore, that to some extent her movement may have contributed to the force of the blow."

The Court evidently inclines to my view. Mr. Hillhouse propounds a theory which means that the Storstad, 440 ft. long, displacing over 15,000 tons, with its bow locked in the side of the Empress, was swung in a few moments through an angle of 100 deg. by the influence of her reversed propeller assisted by some rudder angle. Certainly I have not yet adduced in my theory anything quite so fantastic as that.

Mr. Hillhouse makes a great point about my theory not agreeing with other evidence submitted to the Court. It would have been a very grave objection to my investigation if it had so agreed. My theory had nothing to do with what happened to the bulkhead to which Mr. Hillhouse refers. I stated in my evidence that it was probably damaged by the Storstad, but not so as to destroy its watertightness. Mr. Hillhouse is naturally anxious to believe that it was. No simpler explanation could be found for the fact that a vessel designed by him to float with two compartments open to the sea foundered so rapidly when only one was apparently bilged. No evidence was produced to show whether the watertight doors in this bulkhead were open or shut. As some of these were coaling doors for purposes of bunker trimming, I believe they were open. If this were so, my theory is immediately found to agree with the evidence of the other witness referred to. In any case the conclusions listed in my paper do not deal with this matter, even indirectly, so that Mr. Hillhouse's criticism in this connection is quite valueless.

To conclude, there is not one of the findings listed in my paper which the Court did not fully endorse, and Lord Mersey and his coadjutors attached enough importance to the method of investigation outlined in my evidence as immediately to arrange for a special inspection by the members of the Court of the damaged Storstad. Their views, endorsing mine, are now matters of record.

New York, June 30, 1916. JOHN REID.

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* By a clerical error the name of Mr. Hillhouse was given as "Hillyer" in the report of the discussion here referred to.—ED. E.

STEEL RAILS IN GERMANY.

THE Prussian State Railway Department have recently revised their contract with the Steel Union in regard to the State requirements of rails, sleepers and their accessories. The former arrangement, which held good for another year, has been superseded by a new agreement for three years, the price for rails having been raised 15 marks per ton and is now standing at 129 marks per ton. This increase in price is considered moderate, since the price for other products of the Steel Union has been raised as much as 50 per cent. At the same time it means an extra 15 per cent. to the Steel Union on the deliveries during the first year, but the Railway Department is probably of opinion that the present time is more favourable for making a forward contract than will be the earlier portion of 1917, when a fresh agreement in any case would have to be entered upon. If the war were still going on at that time, an advance of 15 marks would in all probability be declined as insufficient by the Steel Union, and even if, in the meantime, peace had been concluded, it is doubtful whether the quotations for steel and iron products would all at once descend to normal figures. A too sudden fall in the general level of industrial quotations is likely to be averted by the amount of repair work which will have to be taken in hand. The State railways are holding back all work that is not particularly urgent, and the steel and iron works are by no means keen about the manufacture of rails at a nominal profit, when it pays them much better to push the manufacture of half-finished products. This is evidenced by the aggregate of railway material (rails, &c.), which in the year 1914–15 only amounted to 1,759,115 tons, against 2,748,728 tons during the preceding year. The Railway Department, which has been unable to avail itself adequately of the low prices for rails, will have to complete its supplies at the advanced price.

The rise in the quotations for rails is not considered likely to give a further impetus to the upward movement on the manufactured steel and iron market. The attempts to raise the prices of Siegerland ore and of the Pig-Iron Union have been modified. For some time to come there will be no question of any further rise in the quotations in the iron market as far as the leading commodities are concerned.

AUSTRIAN SHIPBUILDING INDUSTRY AND SHIPPING.—The yard of the Austrian Lloyd has, during 1915, employed about 700 men, against 1,000 during the previous year, and repairs were effected on 23 of the company's steamers, against 99 during the previous year, the tonnage being respectively 39, 714 tons and 345,397 tons. Of other steamers, 27 were repaired, against 61 during the previous year. The large dock was in use on 43 working days, against 255 days during the previous year, the small dock on 152 working days, against 265 days during the previous year. The Austrian Lloyd made during 1914 a loss of 4,720,000 kr., which was covered by the reserve; for 1915 the loss, by reducing the writings-off to one-third, comes out at 5,020,000 kr., which absorbs the rest of the reserve capital, 3,260,000 kr., so that only 1,760,000 kr. is carried forward as loss. The other large Austrian shipping concern, the United Austro-Americana Fratelli Consulich, has carried forward an aggregate loss for the last two years of 10,990,000 kr. Since the yard at Monfalcone was occupied by troops in June, shipbuilding has entirely ceased, but materials for the ships in course of construction have been secured and are being worked up at home establishments. The company's fleet comprises 31 ocean steamers (including those in course of construction) and 40 smaller vessels.

CANADIAN RAILWAY PROBLEMS.—The construction of railways in Canada commenced in 1836, when 16 miles were brought into operation. In 1915 the corresponding total had grown to 35,000 miles. The capitalisation of Canadian railways to the close of June, 1915, totaled 1,875,810,888 dols. This sum was made up as follows:—Stocks, 847,801,101 dols.; consolidated debenture stock, 176,284,882 dols.; and funded debt, 851,724,905 dols. As regards public land grant aid given to Canadian railways, and cash assistance rendered to the close of June, 1915, the totals come out as follows:—Dominion Government, 183,479,192 dols.; provincial governments, 37,437,895 dols.; and municipalities, 17,914,836 dols.; making an aggregate of 238,831,923 dols. The Dominion Government has also constructed the Eastern division of the National Transcontinental Railway, upon which an expenditure of 152,802,746 dols. had been made to the close of March, 1915. Cash aid has also been given by Canadian provinces to the extent of 37,437,895 dols., while the cash assistance by municipalities was 17,914,836 dols. Land grants have been made to Canadian railways to the extent of 43,929,312 acres, viz., Dominion, 31,864,074 acres; Province of Quebec, 1,514,013 acres; British Columbia, 8,119,221 acres; New Brunswick, 1,647,772 acres; Nova Scotia, 160,000 acres; and Ontario, 624,232 acres. Canadian railway bonds have been guaranteed to the extent of 350,622,918 dols.; of these guarantees 273,642,663 dols. were considered to have been earned. The Dominion Government had last year guaranteed bonds to the extent of 174,740,856 dols., of which 160,516,649 dols. were considered to have been earned; other guarantees had been given by Manitoba, Alberta, Saskatchewan, Ontario, British Columbia, New Brunswick and Quebec. The opinion of the late Mr. J. J. Hill as to the Canadian railway future should not be forgotten. When in Montreal not so very long ago Mr. Hill said Canada had about enough railway mileage, and he did not believe the policy of the Federal Government—in subsidising railways—was wise, as it caused lines to be built which would not pay for a long time to come.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 5.

QUITE a number of orders from different Governments have been received calling for execution during the third quarter of this year and the first quarter of next. Australia has placed an order for 20,000 tons of steel rails, Great Britain 10,000 tons, and France 12,000 tons for delivery next year. An order has been about placed by the Russian Government for 240,000 steel rails, the bulk of which will be rolled by the United States Steel Corporation. So far as munition orders indicate there is no probability of a termination of dependence on this side for war material. Russia is the largest buyer, and still larger requirements are known of as likely to come forward during the course of the year. All the great steel-making concerns speak of an accumulation of necessities for steel products which will probably be ordered before the close of the summer.

Large sales of pig-iron have been made this week for export, and the volume of this business, according to current inquiries, will be exceedingly large during the current month. The European demand for pig-iron is temporarily checking a sagging tendency in prices. This tendency was not foreseen and cannot be easily explained on the basis of the withholding of much domestic demand coupled by an unexpected expansion of producing capacity; the output of every furnace has been strained to the limit. Steel capacity continues to be expanded with all possible speed. The productive capacity of the country has proved to be a surprise even to the steelmakers themselves. Present conditions are serving as a warning to domestic consumers not to order too far ahead. Munition-making activities are being exerted to the very highest limit and exports are increasing every week. Shipping facilities have improved materially within the past week or two; more relief is in sight.

TRADE OF NEW SOUTH WALES.—The oversea imports during March, 1916, were valued at 1,814,847*l.*, and show an increase of 505,160*l.*, or 21.8 per cent., as compared with the corresponding month of last year. The total for the nine months July to March was 24,738,522*l.*, an increase of 3,108,486*l.*, or 14.4 per cent., in comparison with the figures for 1914–15. The principal articles to show increases were apparel and soft goods, cordage and twines, fish, hats and caps, iron and steel, preserved milk, tea and tobacco, &c. The oversea exports during March amounted to 2,997,538*l.*, being a decrease of 103,778*l.*, or 3.3 per cent., as compared with the corresponding month of last year. For the nine months July to March the exports amounted to 31,661,458*l.*, being an increase of 10,580,208*l.*, or 50.2 per cent., compared with the same period for 1914–15.

THE SPANISH COAL AND IRON TRADE.—The Spanish coal output in 1914 amounted to 3,905,080 metric tons, of which 2,457,613 tons proceeded from the province of Oviedo. The lignite yield was 291,057 tons. The iron ore output reached a total of 6,819,964 tons, or a falling-off of 3,000,000 tons compared with the yield for 1913. The greatest yield was obtained from the province of Vizcaya, with 2,618,150 tons, followed by Santander and Almeria with about 1,000,000 tons each. The output of manganese ore in 1913 was over 21,000 tons, and in 1914 just over 13,000 tons, in which the province of Huelva contributed 9,375 tons. In 1914 Spain produced 382,044 tons of pig-iron and 330,000 tons of iron and steel. The men employed in iron and steel works numbered 24,500 in 1914, whilst the plant comprised 21 blast-furnaces, 38 puddling furnaces, 27 open-hearth furnaces and 7 converters.

AGRICULTURAL MACHINERY.—The war has almost entirely suspended the exports of agricultural machinery from the United Kingdom. In June this year these exports only amounted to 260 tons, as compared with 367 tons in June, 1915, and 3,282 tons in June, 1914. In the six months ended June 30 this year agricultural machinery was shipped to the extent of 1,759 tons, as compared with 2,197 tons in the first half of 1915 and 18,958 tons in the first half of 1914. Germany and Austria formerly imported British agricultural machinery and took 12,834 tons in the first half of 1914; now exports to these hostile countries are, of course, at an end. Exports to Australia have shown a margin of stability, but they are still disappointing; they amounted in the first half of this year to 290 tons, as compared with 163 tons and 368 tons in the corresponding periods of 1915 and 1914. The value of the agricultural machinery exported to June 30 this year was 85,537*l.*, as compared with 103,443*l.* and 856,899*l.* respectively.

FIRE PROTECTION ON BOARD SHIP.—The British Fire Prevention Committee have issued, as Red Book No. 203, some important papers on "Fire Protection for Passenger Ships," the present publication being intended to be useful to shipowners, shipbuilders, and their technical advisers, when considering schemes for laying down the new mercantile tonnage for post-war purposes. The principal section of the Red Book deals with fire protection for passenger ships of over 1,000 tons (gross tonnage), and this section is subdivided under the headings:—(*a*) Ship Fires and Fire Records; (*b*) Preventable Causes of Fire on Board Ship; (*c*) Discovery of Fires on Board Ship; (*d*) First-Aid Fire Appliances on Board Ship; (*e*) Main Fire Appliances on Board Ship; and (*f*) Ship's Fire Service. The publication is obtainable at the Committee's offices, 8, Waterloo-place, Pall Mall, London (3*s.* 6*d.*), and an additional publication is promised on the question of constructional fire posts on board ship.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—There is still no news to record in connection with the pig-iron warrant market, which remains closed. The stocks of Scotch pig-iron in store in Glasgow continue to stand at 1,000 tons.

Scotch Steel Trade.—Never, perhaps, since the institution of Glasgow Fair by the famous Bishop Jocelyn have the Clyde workmen been known to work on Fair Saturday, except on such occasions as it fell to one or two "gangs" to remain behind their fellows to undertake necessary repairs to plant and machinery; but the exigencies of war make all things different, and last Saturday, instead of being the one great holiday of the year, was simply an ordinary working day, with every man keen to turn out as much war material as possible. The events of the past fortnight have increased the demands of both the Admiralty and the War Office, and in every establishment employed on Government contracts it is essential that the high-pressure conditions now ruling be maintained. Unceasing activity, therefore, prevails on all sides, every effort being made to speed up the output. For the most part prices keep steady, a slightly hardening tendency being evident at times, although there is little chance of any change, either up or down, in the immediate future. Little ordinary mercantile export business can be put through under the existing stringent regulations. For export, ship-plates are still quoted 14*l.* 15*s.* to 15*l.* (not 16*l.* as erroneously mentioned last week), or thereabouts; boiler-plates go up from 15*l.* 15*s.* per ton; and angles are 14*l.* 2*s.* 6*d.*

Malleable-Iron Trade.—Like every other branch of the iron and steel industry, the greatest activity continues to mark the malleable-iron trade; in fact, manufacturers are experiencing the utmost difficulty in overtaking the orders which are pressed upon them, both in the iron and steel departments. One result is that there is a distinct firming in the price of the steel products. With the extensive demand of Government for the smaller-sized bars, little export business is practicable, and this branch is therefore much curtailed, and no licence being required, this might otherwise be a most profitable "line." Prices for "Crown" bars for export keep steady at 14*l.* 2*s.* 6*d.* per ton or thereabouts, and for home delivery 14*l.* 12*s.* 6*d.*, less 5 per cent. discount.

Scotch Pig-Iron Trade.—While hematite continues to be much in demand, the ordinary grades of pig-iron are, at the moment, rather quieter than they have been for some time past, although it may be, of course, that the licensing restrictions on export have set free for home consumption a quantity much in excess of what has been available lately. All the same, makers are making considerable inroads on their stocks. No change in price of makers' (No. 1) iron has taken place for some weeks now, the old rate still ruling. Little export business is being put through and the deliveries of ore are so uncertain as to cause some considerable anxiety.

The Postponement of Holiday Question.—It would be ridiculous to assume other than that the Clyde workers engaged on munitions and other Government contracts are greatly disappointed at the idea of a further postponement of their much-needed holiday; yet, notwithstanding, they have loyally grasped the seriousness of the situation upon which hangs the ultimate success of the gigantic struggle now in progress. Leaving their own desire for a cessation of labour aside, they realise that the present momentous offensive on the Western front cannot be maintained without a continuous and unstinted supply of the necessary war material. The question in all its bearings was fully discussed at a meeting of the Clyde Local Advisory Board held in Glasgow on Monday afternoon, when the secretary, Mr. T. D. Matthew, was appointed the Board's representative to the conference of trade union officials convened in London for yesterday. Some considerable attention was given to the effect, both upon men and women munition workers, of the strain of continuous labour without a break, and a statement expressing the opinion of the Board upon the subject was drafted for presentation to the London meeting. The decision of the conference to postpone all holidays in compliance with the Government's recommendation has in no way surprised any one, and the workers have accepted the conditions in very good part, confident that their representatives had no alternative but to approve the suggested postponement of the holiday.

JAPANESE CHEMICALS.—The Japanese Home Office says the *London and China Telegraph*, has been encouraging the production of chemicals and drugs in Japan in order to make up the shortage in the imports of these goods resulting from the European war. As the result of a recent official investigation, it is stated that numerous chemicals and drugs are now being produced in Japan. The enormous rise in the price of dyestuffs has caused dye-making concerns to be started in various places in Japan. The production of vegetable dyes, for some time neglected, has been recommenced, and the scientific process of making synthetic dyes is being studied. Already the manufacture of synthetic dyes in black and brown has been started on a small scale. The output of phosphorus by Japanese works is increasing, as is also the production of sulphate of ammonia. The total quantity of sulphate of ammonia which will be manufactured in Japan this year is stated to be 41,800 tons. It is estimated that the Japanese demand for oxygen for industrial purposes can be nearly satisfied by the output of Japanese companies, which is said to amount to about 2,000,000 cub. ft. per annum.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—There is a strong tone in the market for all classes of fuel other than house coal, and the falling-off in this section is equalised by the heavier inquiries by gas companies and shippers. Chief interest centres in the shipments. Freights are in no sense easier, but there is greater tonnage available, and the quantities going away are higher than for many weeks past. Preference is given to shipments for the Allied Powers, and to France and Italy especially has the trade been heavy, both in the best steams and the lighter coal. Prices for open market sales to neutrals are still of a very satisfactory character to the collieries, and there has been a keen desire to do all the business possible in this line, with the consequence that the home market has not offered buyers the same freedom of choice outside of contracts. The renewal of the gas companies' contracts has now been arranged upon agreed terms, which in the majority of cases are the terms which last year's contracts were fixed at prior to the adoption of the Coal Prices (Limitation) Act, so that the collieries are in certain cases getting a slight concession above the official maximum. The local demand for manufacturing coal keeps the pits at full working capacity, for the requirements of the munition works and the railways are increasing rapidly. The system of the Government Committee in directing supplies continues to answer satisfactorily, and there is no present shortage, though the works' managements are eager to get reserves built up, which the prevailing abnormal demands will not allow. The active demand is for best steams, cobbles, nuts and hards, but slacks are just a shade easier, and have been more freely purchased than heretofore. Cokes are still firm, and the current high prices are well maintained. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.*

Iron and Steel.—The market for all classes of iron has been very busy, for buying has been on a greater scale than usual. The consumption in Sheffield is now heavier than at any previous war period, and the makers are severely taxed to meet all demands. The scarcity continues to be most marked in regard to hematites, but the conversion of many of the furnaces, which has now taken place, has eased the position a little. West Coast brands are freely asked for, and there has also been large transactions in the East Coast varieties. Lincolnshire and Derbyshire foundry makers are finding renewed activity in their particular lines, whilst the inquiries for forge qualities are on a much higher scale. There is very little acid steel on offer, and the Bessemer brands have now advanced to fully 15*l.* Swedish supplies are dwindling down, whilst the Sheffield houses are loth to pay the extravagant figures asked for the small available American tonnage. Interest is again centred in the scrap-metal position. Dealers here express the opinion that a maximum for prices is unworkable, for it does not allow for the variations in the quality of the metal nor the different localities. One of the principal topics is the question of the postponement of the Bank Holiday in August. There is little fear that Sheffield will not fall heartily into line as in the case of the postponement of the Whitsuntide vacation. Meetings of the masters take place early this coming week, whilst the men have yet to confer, though it is felt there is not much doubt as to the stand they will take, especially if the same conditions obtain as in the earlier case. At the expressed desire of the munition authorities in London, the several works' managements that have extensions on hand are having the work proceeded with as expeditiously as possible. The unsettled weather has been a handicap in completing the schemes, many of which are on a very large scale, but an effort is now to be made to pursue the tasks in face of all disadvantages. It is anticipated that in the very near future there will be an accession of several thousand more female workers to the ranks of the Sheffield artisans. There is also a steady movement on foot to prepare for after-war trade, and certain manufacturers are now taking active steps to cover the possible fields of trade with advance agents in the shape of experienced commercial travellers. A new Government order is for chisels, whilst other shipbuilding tools are wanted in equally large proportions. For the Army, cooks' and butchers' knives and mattocks have been ordered. Another firm to adopt the electric furnace is that of Messrs. Rossall and Co., who have just installed a new type with a capacity for 30 cwt. One of the most pleasing features of the past few weeks is the growing evidence that the revival of the export trade, which we noted some short time ago, seems to have at length secured a permanent basis. The colonies are becoming very much bigger customers for all classes of Sheffield goods and the increased trade is most marked in the case of Canada. The South American market has also improved. Recent mails from overseas have brought large orders for steel, steel wire, cutlery, electro-plate, implements, tools, &c.

THE TRANS-AUSTRALIAN RAILWAY.—It is anticipated that plate-laying at the western end of the trans-Australian railway (which has been stopped owing to the shortage of rails) will commence again almost immediately. The Broken Hill Proprietary Company have undertaken to supply a minimum quantity of 3,000 tons of rails per month.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

Cleveland Iron.—Much firmness continues to characterise Cleveland pig-iron, but business is still somewhat inanimate. So far as the home trade is concerned, however, more disposition to operate is noticeable, and merchants are transacting more business, consumers being rather anxious to make up stocks. The permission granted merchants to charge 1½ per cent. commission above fixed maximum prices has been a good deal discussed. It is understood that where credit extends beyond the 10th of the following month a charge of 6*d.* per ton per month may be added. Merchants consider that the terms are too low, especially with the present Bank rate. For home consumption No. 3 Cleveland pig-iron stands at 87*s.* 6*d.*, and that price also rules for No. 4 foundry and for No. 4 forge, whilst No. 1 is 91*s.* 6*d.* As regards export, trade licences for shipment to the Allies are less difficult to secure, but the volume of new business is still very small. The export price of No. 3 runs from 95*s.* to 97*s.* 6*d.*, and No. 1 is in the neighbourhood of 100*s.* for shipment abroad.

Stocks of Cleveland Pig-Iron.—The stock of Cleveland pig-iron in the public warrant stores here has now been reduced to 26,057 tons, and consists of 25,312 tons of No. 3 quality, and 745 tons of other descriptions of iron deliverable as standard. Since the beginning of the month 2,613 tons of No. 3 and 800 tons of standard iron, a total of 3,413 tons, have been taken from the stores.

Hematite Iron.—Demand for East Coast hematite iron is pressing, but home requirements are fairly well met under the prevailing conditions, and deliveries to our Allies are regular. Consumers in France are able to purchase at the same rate as home users, viz., 122*s.* 6*d.* for Nos. 1, 2 and 3; but for general export mixed numbers are 140*s.* and upward.

Pig-Iron Shipments.—Shipments of pig-iron from the Tees cannot, under all the circumstances, be regarded as unsatisfactory. So far this month they amount to 31,254 tons, as compared with 23,735 tons to the same date last month, and 26,457 tons for the corresponding part of July last year.

Coke.—Coke is coming forward better, but is well taken up, and there is none to spare. Local requirements are heavy, and likely to increase. Average blastfurnace kinds readily realise 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is named for qualities low in phosphorus. For shipment, best foundry coke is round about 47*s.* 6*d.*, and gas-house coke 34*s.* to 35*s.*

Foreign Ore.—Continued very excellent deliveries of foreign ore on running contracts, and the fact that consumers are carrying considerable stocks, do not check the upward tendency of values. Imports to Middlesbrough so far this month reach no less than 168,606 tons. Rubio of 50 per cent. quality is 38*s.* ex-ship Tees on the official 17*s.* freight basis Bilbao-Middlesbrough, the rate at which controlled consumers are privileged to have the ore conveyed. In the ordinary way in the open market the freight is 19*s.*, and up to 40*s.* ex-ship Tees is asked for best Rubio. The f.o.b. price at Bilbao of 50 per cent. Rubio is stated to be fully 20*s.*

Manufactured Iron and Steel.—As the capacity of producers of manufactured iron and steel is almost entirely absorbed by Government work, the rather numerous ordinary commercial inquiries in the market receive little attention. The following are among the principal market quotations:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; steel bars (no test), 14*l.* 10*s.*; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 5*s.*; iron and steel ship plates, 11*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; iron ship rivets (¾-in. diameter), 17*l.* 10*s.*; iron ship rivets (⅞-in. diameter), 18*l.* 10*s.*; steel ship rivets (¾-in. diameter), 18*l.* 10*s.*; steel ship rivets (⅞-in. diameter), 19*l.* 10*s.*; steel strip, 17*l.*; steel for hoops, 17*l.* 10*s.*; and steel joists, 11*l.* 2*s.* 6*d.*

Steel Scrap.—With the fixing of maximum prices steel scrap, business, which has been held up, has opened out. Heavy steel scrap is 5*l.* 10*s.*, and steel turnings 2*l.* 15*s.*

Trade Statistics.—The quarterly returns of the Middlesbrough Chamber of Commerce issued this week show the total value of goods, other than coal and coke, exported to foreign and Colonial destinations from the port of Middlesbrough for the three months ended June 30 last amounted to 4,364,687*l.* and for the half-year to 7,818,665*l.*, compared with 1,882,467*l.* for the second quarter of last year, and 3,371,094*l.* for the first half of 1915. At the end of June, of 77 blastfurnaces erected at Middlesbrough 45 were in operation, the number blowing being one more than a year ago. The production of pig-iron during the second quarter of the year is given at 552,000 tons, of which 236,000 tons were Cleveland pig, and 316,000 tons hematite, spiegel, basic, and other special irons. For the previous three months the output totalled 551,000 tons, composed of 236,000 tons of Cleveland, and 315,000 tons of other kinds of iron; and for the second quarter of 1915 the make amounted to 536,000 tons, 279,000 tons being Cleveland pig, and 257,000 tons hematite, &c. Imports of foreign ore to Middlesbrough last quarter reached 605,717 tons, as compared with 441,021 tons for the previous three months, and 452,862 tons for the second quarter of last year.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam coal trade has remained quiet. The tonnage movement has been unsatisfactory, but colliery outputs have been maintained; and as the authorities have been taking reduced quantities, there has been more coal for disposal in the open market. Colliery owners have been quoting 45*s.* to 47*s.* per ton for second Admiralties, as they anticipate renewed pressure as soon as arrangements for shipments to France under the limitation of prices scheme have been completed. House coal has been advanced 6*d.* per ton, in accordance with a recent decision of the Board of Trade with respect to the limitation price. Patent fuel and coke have been scarce and strong. The best Admiralty large steam coal has been to some extent nominal; Monmouthshire Black Veins have made 45*s.* to 47*s.*; ordinary Western Valleys, 45*s.* to 46*s.*; Eastern Valleys, 42*s.* to 44*s.*; best bunker smalls, 28*s.* to 30*s.*; and cargo smalls, 20*s.* to 23*s.* per ton. In bituminous coal, best households have been making 25*s.* to 26*s.* per ton at the pits; No. 3 Rhondda large, 47*s.* to 48*s.*; smalls, 32*s.* to 34*s.*; No. 2 Rhondda, large, 35*s.* to 37*s.*; and No. 2 smalls, 22*s.* to 23*s.* per ton. The latest quotation for patent fuel has been 50*s.* to 51*s.* per ton.; Special foundry coke for export has made 62*s.* to 65*s.* good foundry coke, 60*s.* to 62*s.* 6*d.*; and furnace coke, 50*s.* to 55*s.* per ton.

Western Trade Matters.—The directors of the Gloucester Railway Carriage and Wagon Company, Limited, report a profit for the past financial year of 47,750*l.* The directors transfer 10,000*l.* to the reserve fund, and they recommend a dividend for the past half-year at the rate of 10 per cent. per annum, carrying forward 49,104*l.* The company now repairs and maintains 30,240 wagons. Mr. William Law has resigned the post of general manager of Swansea Harbour. Mr. Law held office for 24 years, having been appointed general superintendent of the docks in 1892. In that year the normal tonnage movement of the port was less than 3,000,000 tons; it has now risen to upwards of 7,000,000 tons. When Mr. Law was appointed, the Prince of Wales Dock had just been extended and the accommodation of the port had been increased by some 50 per cent., but the construction of the King's Dock was, of course, the most important event in the commercial history of Swansea.—The High Court Official Referees Court has been occupied with a claim of Messrs. Maxted and Knott, consulting engineers, against the Aberthaw and Rhoos Portland Cement Company, of Cardiff, for fees in connection with the construction of the defendants' cement works at Rhoos. The amount of the claim was 5,356*l.* The hearing of the case has extended over several days.—An interim dividend at the rate of 10 per cent. per annum has been announced by Graham's Navigation (Merthyr) Collieries, Limited; the dividend is payable July 29. The 200,000 new ordinary shares of 1*l.* each proposed to be issued by the Ebbw Vale Steel, Iron and Coal Company, Limited, are to be offered in the first instance to the existing shareholders.—The steel steamer Tanasa, built at Goole in 1909, and 350 tons deadweight, has been sold to Elano, Wright and Martinez, Limited, Cardiff, for 15,000*l.* Elano, Wright and Martinez, Limited, have also purchased the steel steamer Enterprise, built at Sunderland in 1905, and 1,650 tons deadweight, for 35,000*l.*—D. Davis and Sons, Limited, have announced an interim dividend at the rate of 20 per cent. per annum for the half-year ended June 30; a distribution of bonus shares is also to be made to the shareholders in respect of accumulated profits as soon as possible. The directors, at a meeting in London, Lord Rhondda presiding, appointed Mr. W. B. Laws (assistant general manager), as general manager at Cardiff. Mr. F. Llewellyn Joseph has been appointed general manager of the collieries at Ferndale and Coedely.—Professor Irvine, acting on behalf of the Board of Trade, presided at a conference held at Cardiff on Thursday to consider what steps should be taken to mitigate the continuous labour troubles which arise in Welsh ports, and especially in connection with coal trimming. A resolution was agreed to establishing a central trimming board for the whole of South Wales. The W. and C. T. Jones Steamship Company, Limited, returns its profits for 1915–16 at 204,805*l.*, as compared with 90,875*l.* for 1914–15. The directors have increased the reserves to 119,000*l.*, as compared with 40,000*l.* 12 months ago. The dividend for 1915–16 is proposed to be at the rate of 25 per cent. per annum, as compared with 10 per cent. per annum in 1913 and 1915, and 5 per cent. per annum in 1911, 1912 and 1914.—A new process of preparing plates for tinning is now in operation at the Mellingriffith Works. The new method dispenses with the necessity of white pickling, and will enable 2,000 boxes to be turned out in a week.

RADIOGRAPHS OF FERRO-CONCRETE.—A promising examination of ferro-concrete by the aid of Röntgen rays is mentioned by Mr. E. Stettler, of the Swiss Railway Department, in the *Schweizerische Bauzeitung* of June 15. A plate, 18 by 24 cm., 7.5 cm. (3 in.) thick, was built up of ordinary concrete and commercial iron rods, 7 mm. in thickness; the plate was examined in the Röntgen Institute of Berne. The first radiograph obtained, which is reproduced in the journal mentioned, does not show more than the dark shadings of the crossing rods on a less dark background, and the somewhat imperfect hook joint formed by two of the rods. But cracks in the concrete and indications of rusting, if present, would probably also be perceptible. The examination is quite easy and cannot do any harm to the building, and the distribution of the rods in the finished product could at any rate be studied if the process were applicable on a large scale.

SEWAGE PURIFICATION PLANT AT PONT-Y-WAL SANATORIUM, TALGARTH, BRECON.

CONSTRUCTED BY MESSRS. TUKE AND BELL, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 56.)

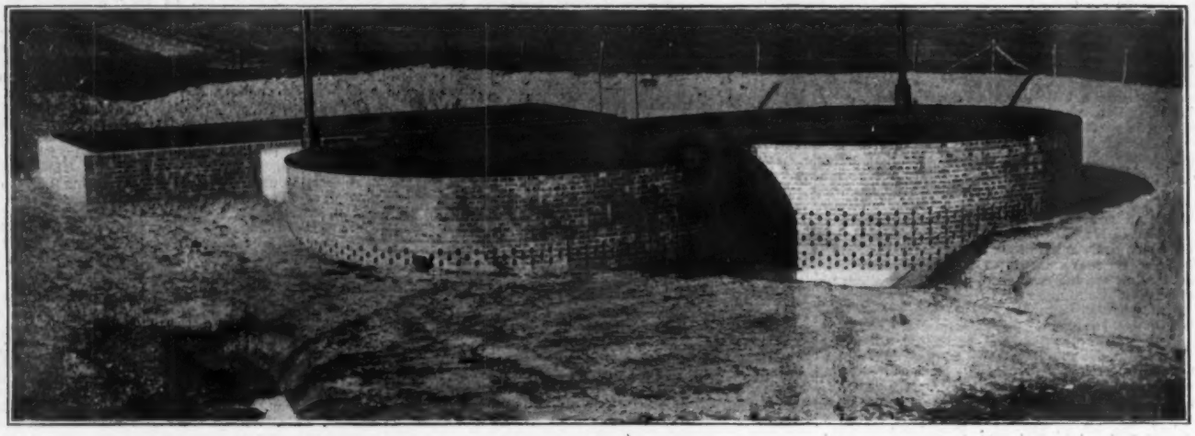


FIG. 5. PRIMARY AEROBIC FILTERS.

FIG. 6. THE FINISHING FILTER.

LAGOS.—Lagos possesses a Municipal Board of Health, but since no rates are levied, the revenue of the Board is chiefly derived from Government grants. The average annual grant from revenue for the past five years stands at 17,280*l*. In addition, large sums have been expended from general revenue in reclamation of swamp land, general sanitary improvements, the laying out of a marine sea front, &c. The town is lighted by electricity, for which no charge is made upon municipal funds. Waterworks at Iju, 17 miles from Lagos, which were commenced in October, 1910, were practically completed in 1914, although the supply was not actually inaugurated until the following year. The volume of the Adiyan, the stream from which the water is obtained, is calculated at 6,500,000 gallons per diem. The water is pumped from two 12-ft. wells by two drawing and three forcing engines into two settling tanks with a capacity of 10,000,000 gallons. From these tanks it passes to eight filter beds and thence to a clear-water tank, which has a storage capacity of 2,000,000 gallons and is floored and roofed with concrete. From this tank the service reservoir (6,000,000 gallons) is supplied. From the reservoir (which has also a concrete roof, so that the water is not again exposed to the air after it leaves the filter beds) the water is conveyed by gravitation through 26-in. pipes to Lagos and Ebute Metta, where it is distributed by mains varying from 3 in. to 15 in., with an aggregate length of 28 miles. The total expenditure made upon the works was 296,700*l*.

INDIAN IRRIGATION.—The recent failure of winter rains in India has illustrated the enormous advantages gained by provinces which have developed extensive irrigation systems. In the Punjaub half the total area under wheat is irrigated by canals; and although a full supply of water was not available, the harvest reaped has still been a large one. The crop, also, was free from rust or smut, and threshed out better than might have been expected. Altogether, the total yield from all areas was 33 per cent. less than that of 1915, the returns from unirrigated tracts being very poor. In the United Provinces 46 per cent. of the wheat area is served by canals and the crop was a good one, although there was a shortage of water. The total yield was 11 per cent. less than last year, but the crop, irrespective of the area sown, was 90 per cent. of an average. Rajputana has usually less than 1,000,000 acres under wheat, and it has fared very badly this year owing to drought, the yield having fallen off 47 per cent. Rajputana would clearly be greatly benefited by irrigation.

THE UNITED STATES NAVY.—According to the *Iron Age*, the advocates of adequate preparedness have won a notable victory in the Senate Committee on Naval Affairs, a sub-committee of which has completely recast the annual naval appropriation Bill as passed by the House. Three Dreadnoughts and four battle cruisers have been substituted for the five battle cruisers authorised by the House measure, and the five-year construction programme, so carefully worked out by the experts of the Navy Department and contemptuously rejected by the House Naval Committee, has been incorporated in the Bill. Another notable addition by the Senate Committee is an increase of 5,000,000 dols. in the appropriation for the manufacture of a reserve supply of ammunition for the Navy. The construction programme authorised by the Senate Committee for the coming year will include 2 Dreadnoughts, 4 battle cruisers, 5 scout cruisers, 10 destroyers, 30 coast submarines, 1 fuel ship, 1 hospital ship, and 1 ammunition ship. The five-year building programme worked out by the Navy Department and adopted by the Senate Committee commits Congress to provide for the construction of the following ships: 10 first-class battleships, 6 battle cruisers, 10 scout cruisers, 50 destroyers, 15 fleet submarines, 75 coast submarines, 1 repair ship, 1 transport, 1 hospital ship, 2 destroyer tenders, 1 fleet submarine tender, 2 ammunition ships, 4 river gunboats and 3 fuel-oil ships. The 10 first-class battleships (Dreadnoughts) will carry as heavy armour and as powerful armament as any vessels of their class. They will be designed to develop the highest practicable speed and the greatest desirable radius of action; their cost, exclusive of armour and armament, is not to exceed 11,500,000 dols. each. A hard fight is anticipated over the Naval Bill when it reaches the conference committee which will be appointed to harmonise the conflicting provisions of the House and Senate drafts.

THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY.

(*For Description, see Page 51.*)

FIG. 21. INLET CANAL.

FIG. 22. INLET SLUICES.

FIG. 23. POWER-STATION SEEN FROM DOWN-STREAM

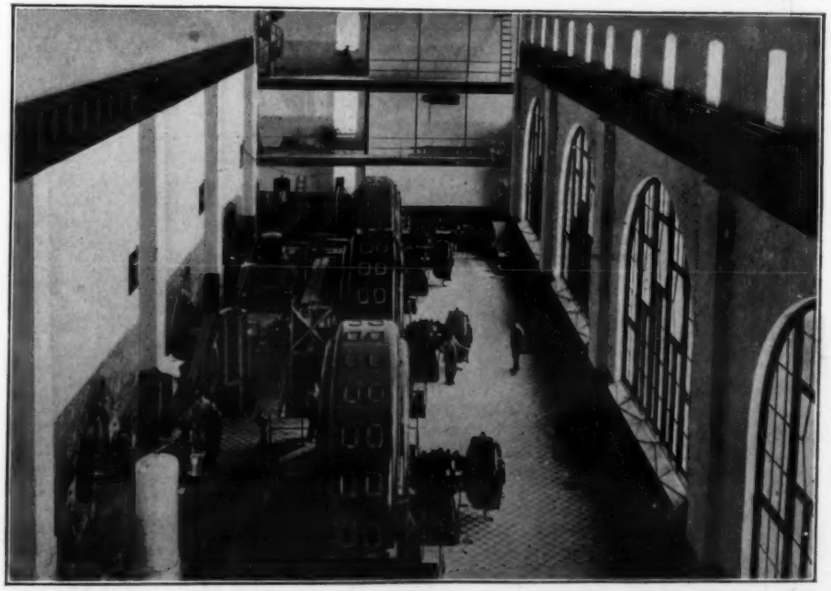


FIG. 24. THE GENERATORS; THE GENERAL SWEDISH ELECTRIC COMPANY, VÄSTERAS.

(*To face page 54.*)

THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY; DETAILS OF EQUIPMENT.

(*For Description, see Page* 51.)

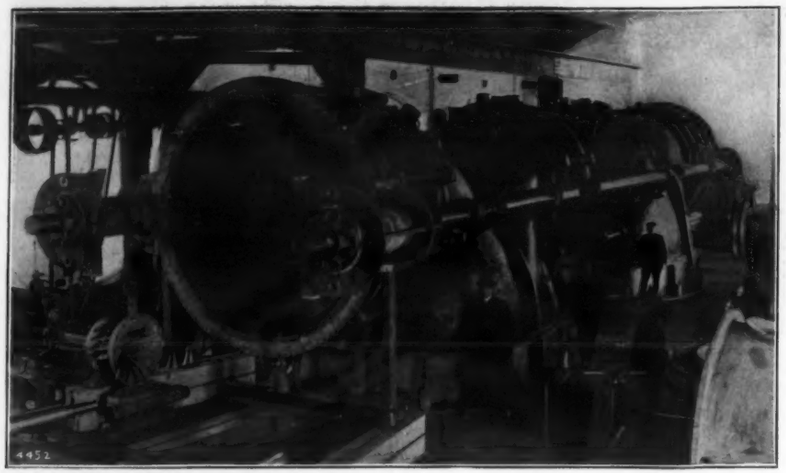


FIG. 25. TURBINE UNDER CONSTRUCTION AT THE KRISTINEHAMN WORKS OF THE KARLSTAD ENGINEERING COMPANY.

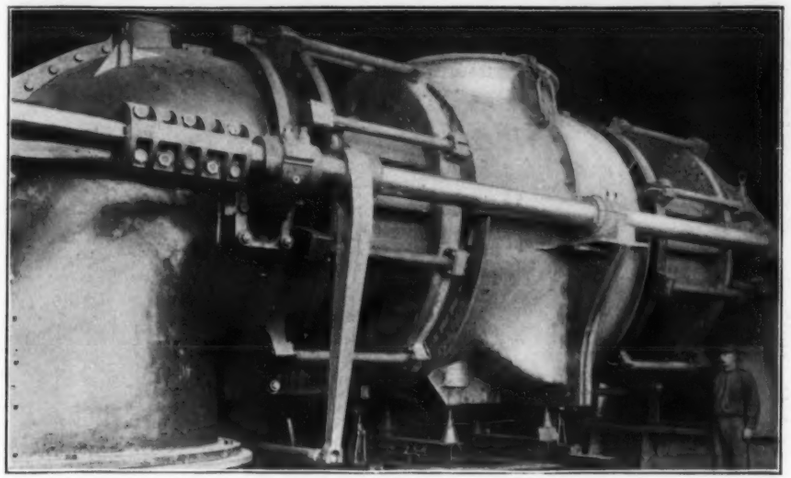


FIG. 26. TURBINE IN COURSE OF ERECTION; THE KARLSTAD ENGINEERING COMPANY, KRISTINEHAMN.

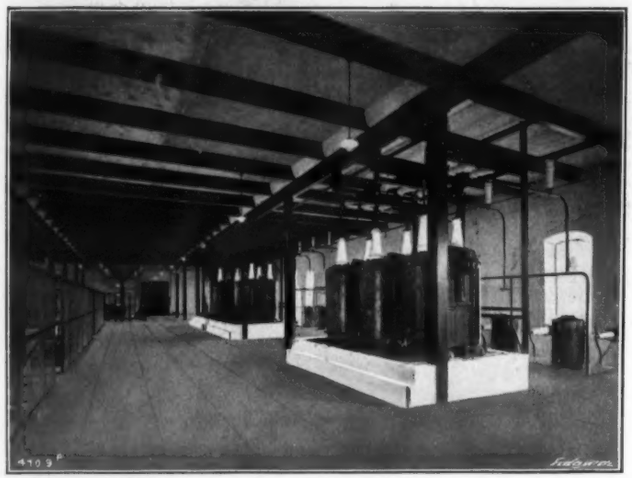


FIG. 27. GROUPS OF TRANSFORMERS; THE NEW UNITED ELECTRIC COMPANY, LUDWIKA, SWEDEN.

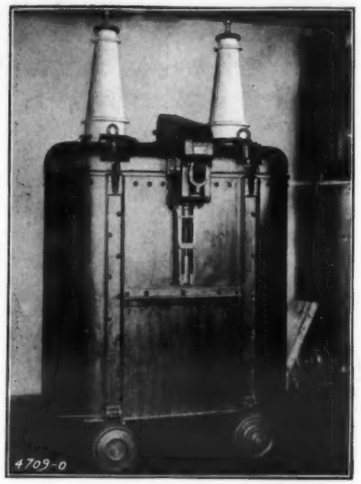


FIG. 28. SINGLE-PHASE TRANSFORMER; THE NEW UNITED ELECTRIC COMPANY, LUDWIKA, SWEDEN.

FIG. 29. VIEW IN INSTRUMENT-HOUSE.

5-TON ELECTRIC CRANES AT THE N. ODERO SHIPYARD, FOCE, GENOA.

CONSTRUCTED BY THE OFFICINE ELETTRO-MECCANICHE, ENGINEERS, RIVAROLO, LIGURE (ITALY).

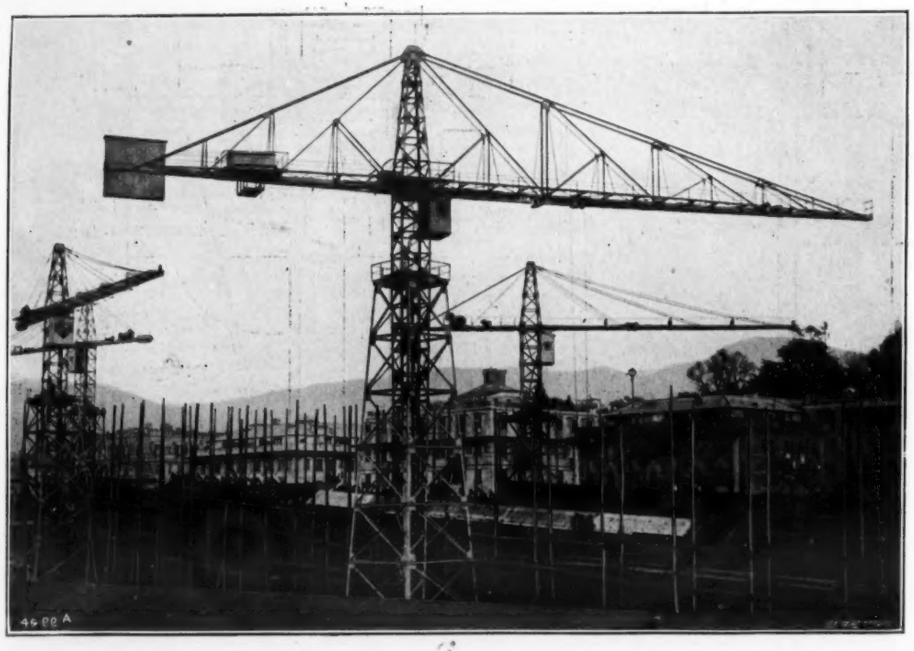


FIG. 1.

Fig. 2

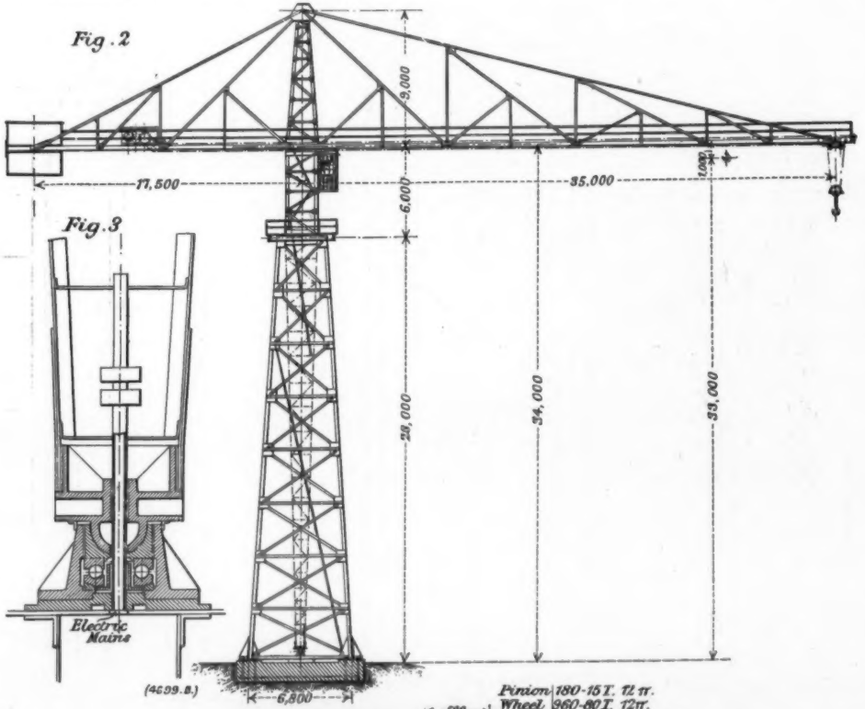


Fig. 3

Fig. 4.

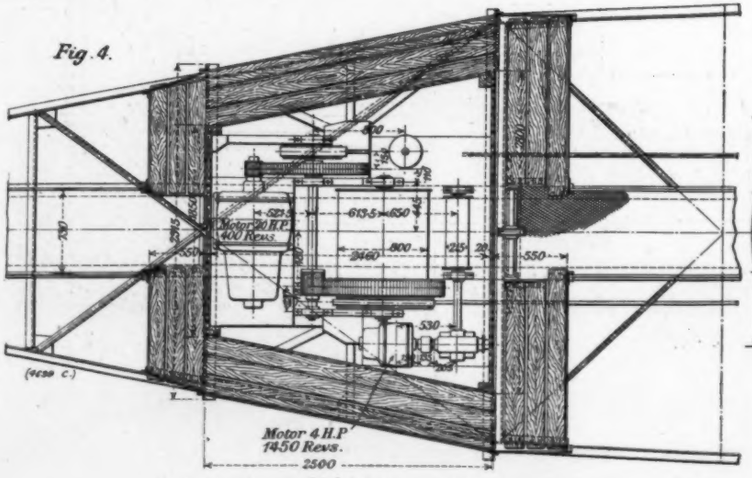


Fig 5.

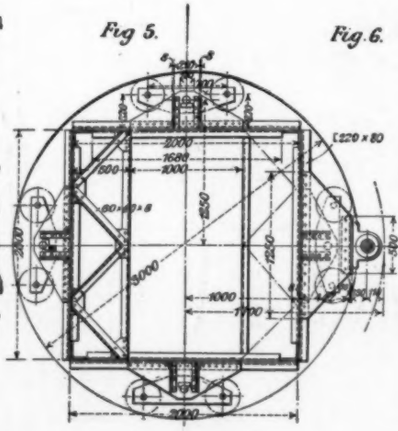
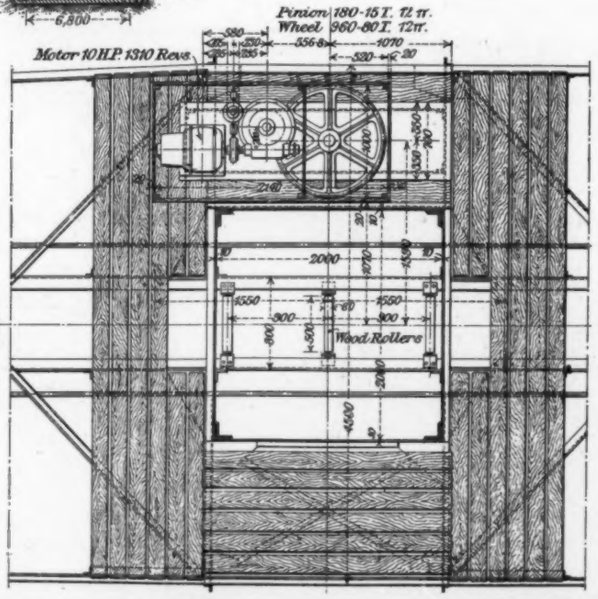


Fig. 6.



5-TON ELECTRIC CRANES AT THE N. ODERO SHIPYARD, FOCE, GENOA.

CONSTRUCTED BY THE OFFICINE ELETTRO-MECCANICHE, ENGINEERS, RIVAROLO, LIGURE (ITALY).

(For Description, see Page 54.)

Fig. 7.

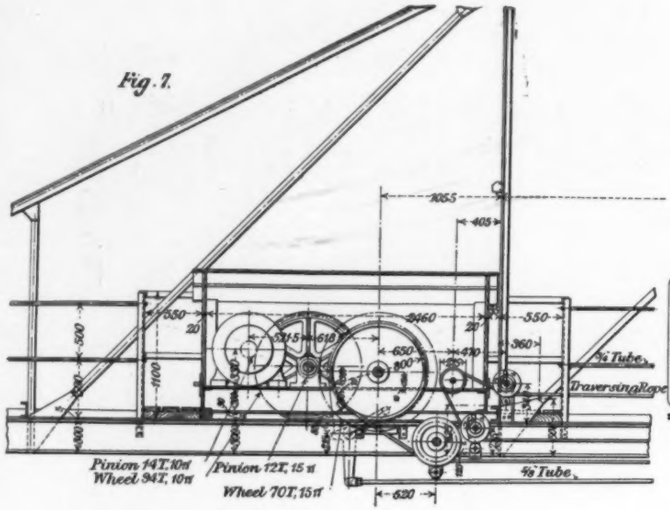


Fig. 8.

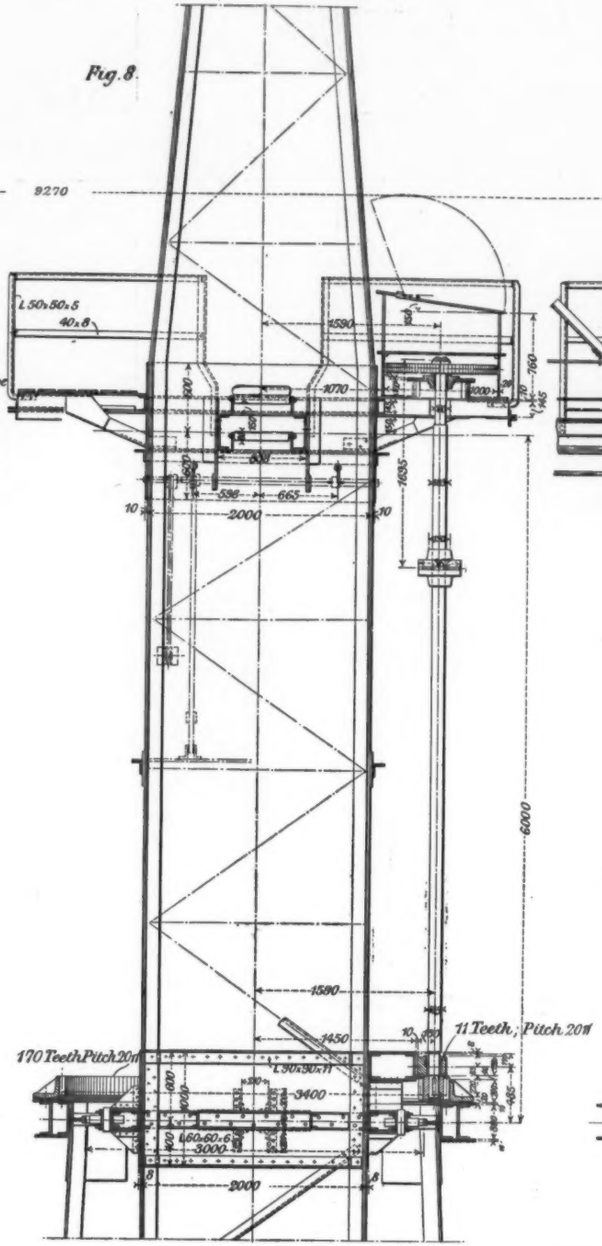


Fig 9

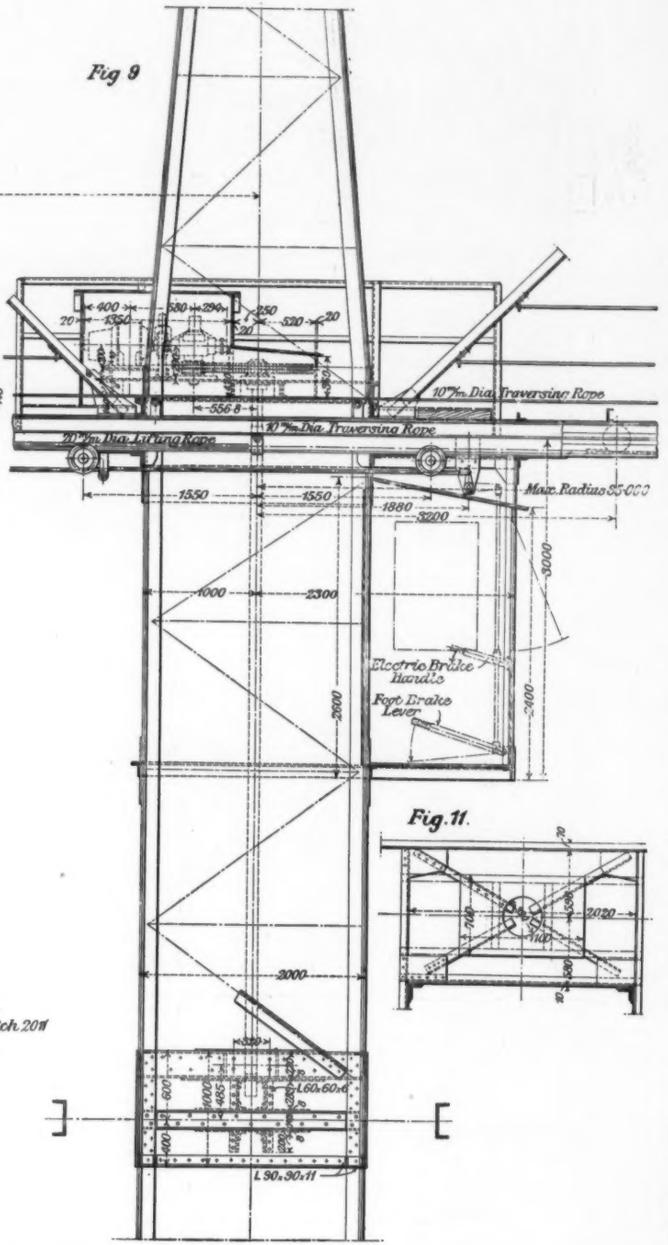


Fig. 10.

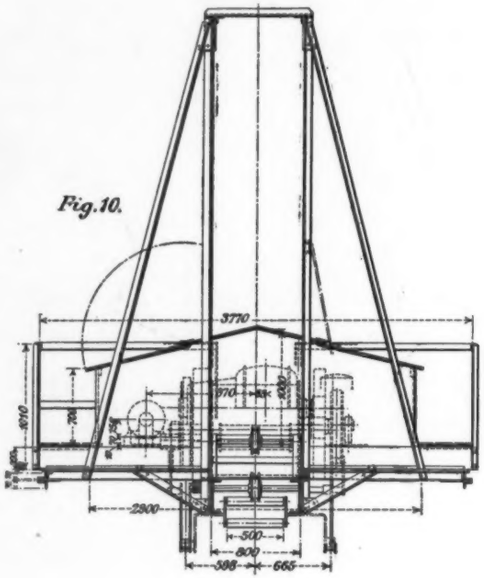


Fig. 11.

(To face page 55.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

CONTENTS.

	PAGE		PAGE
Roads and Paving	51	Notes from South Yorkshire	59
The Swedish State Hydro-Electric Power-Station at Alfkarleby (*Illus.*)	51	Notes from Cleveland and the Northern Counties	59
5-Ton Electric Cranes for Shipyards (*Illustrated*)	54	Notes from the South-West	59
Industrial Notes	55	Our Educational Problem	61
Sewage Purification Plant at Pont-y-Wal Sanatorium, Talgarth, Brecon, (*Illustrated*)	56	The London Tramway Financial Deficit	62
Draughtsmen	56	Notes	63
The "Empress-Storstad" Collision Case	57	Aerodynamical Properties of the Triplane (*Illus.*)	64
Steel Rails in Germany	58	Literature	66
Notes from the United States	58	Books Received	67
Notes from the North	58	Trade War in China	67
		Oil-Engines and Steam-Engines in Combination (*Illustrated*)	68
		Colonial and Foreign Engineering Projects	70

With two One-Page Plates of the SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY, and two One-Page Plates of the 5-TON ELECTRIC CRANES AT THE N. ODERO SHIPYARD, FOCE, GENOA.

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In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 21, 1916.

OUR EDUCATIONAL PROBLEM.

IN his remarks made at the conference held last May on our neglect of science, Mr. Wells observed, we think very truly, that the politicians and the lawyers are likely to remain our rulers to the end of time. This being so, it is incumbent on us, as Robert Lowe observed in another connection, to educate our masters, and this promises to be a work of no little difficulty in view of the strong vested interests involved, and the unwisdom of some of the proposals advanced by certain of the advocates of reform. One common error is that our industries are suffering, and have suffered, from defects in our scheme of elementary education. Little, if any, evidence has so far been advanced in support of this view, our workmen being quite as capable as those of any other nation. There may be, and no doubt are, good reasons for reforms in our primary schools, but, so far as our industries are concerned, the necessity for reform in our system of secondary education is a much more urgent matter. Here, again, however, many seem somewhat inclined to plead for the adoption of methods but little superior to those they criticise. They would specialise in science, just as most secondary schools now specialise in dead languages. Both systems are equally indefensible. Early specialisation is of all things to be avoided as it is of the highest importance that early culture, so far as it goes, should be wide rather than deep. It is accordingly with much pleasure that we note what we take to be a protest against the heuristic school which is made in Dr. Garnett's recent address to the Association of Technical Teachers. Unfortunately this school has gained the ear of the Board of Education with, we conceive, a very unfortunate influence on the scientific work of the department. As Dr. Garnett observes, the spending of many hours daily in elementary laboratory exercises is for the average youth little if any more profitable to his mental development than the corresponding exercises in gerund grinding, which has commonly been his educational fate up to the present.

The doctrine of universal gravitation and the main consequences deducible therefrom can be grasped quite readily by the average youth, without requiring him to waste hours in rough and trivial experiments in a laboratory of mechanics, and his confidence in the doctrine of the conservation of mass will not, if he is intelligent, be materially strengthened by such rough weighings as he can himself make in the chemical laboratory. The connection between mosquitos and malaria, again, does not require for its apprehension even an elementary knowledge of practical biology, and probably no recent generalisation is of more interest and significance than this.

For the general mass of schoolboys we conceive that there is much to be said for the old system in which qualitative experiments were made for them by the lecturer to illustrate the main principles of his subject, the actual establishment of which may have necessitated centuries of effort by the most skilful investigators of all nationalities. These principles are, in their broad outlines, simple and illuminative and will be found of interest even by those who mean to specialise in classics. In fact, the system we advocate for the average youth is very much that which is followed in the lecture courses delivered at the Royal Institution, supplemented, of course, by class work. Few will deny either the interest or the educative value of these lectures, although the experimental illustrations are necessarily more qualitative than quantitative, and but few of the audience would themselves be capable of the precise laboratory work needed to definitely establish the conclusions stated.

Indeed, if the heuristic school is right, scientific lectures of a popular character are wholly indefensible, a view to which we think few of the advocates of the method would subscribe. No doubt these hope that by the system they recommend, the average student will be taught to generalise for himself. This gift is, however, innate and not acquired, and will always be confined to a relatively small fraction of the community. There are many able and keen observers, and even careful experimenters, who lack the faculty. Their observations and results may be accepted, but they fail lamentably when they attempt to pass from the field of observation and experiment to that of deduction.

This proposition has, indeed, been strikingly exemplified during the recent discussion on this very problem of education. Advocates of the existing system have lauded it as specially suitable for producing men fitted for executive posts, basing their argument on the fact that most of those occupying such positions in this country have been educated on the traditional lines. A comparison of the relative records of the Army and Navy, however, knocks the bottom out of the contention. Naval officers receive a training in which classics play no part, whilst for success at Sandhurst classics are necessary, no scientific knowledge whatever being required. The defenders of the above thesis will have some difficulty in persuading the public that the naval officer is inferior in executive or administrative ability to his colleague of the Army. The deficiency in the scientific corps, viz., Artillery and Engineering, which the war has made evident, is probably to some extent attributable to the conditions at Sandhurst. It was impossible to get the authorities to sanction experiments on artillery, for example, which officers of that corps knew to be desirable, and the whole establishment was cut down to the disastrously low limit at which it stood two years ago.

In fact there is not a little evidence to show that our classically trained administrators have proved, in many cases, singularly inept. The capability of writing a readable report covers at present many sins both of omission and commission. Though British investigators bore a leading part in establishing the close connection between mosquitos and certain devastating diseases, it was left to American administrators to make the most striking and effective applications of their teachings. Many are our tropical Crown colonies, but in none of them have the administrators we appoint effected hygienic reforms equal to the marvellous work accomplished at Panama, Havana and Manilla.

Coming to the more restricted question of the best methods of educating engineers, an interesting report has recently been presented to the Council for Organising British Engineering Industry, its authors being Mr. A. P. M. Fleming, of the British Westinghouse Company; Principal Garnett, of the Manchester School of Technology; and Professor Miles Walker.

They observe that those engaged in the engineering industry may be divided into two principal classes, the workers and the thinkers, and that the same training is not the best for both. Of course, the reporters in this premise are dealing with averages. Fortunately in this country the line of demarcation between the manual labourer and the director of an industry is not a fixed and impassable boundary, many of our ablest engineers having risen from the ranks, and whatever system of education is adopted it is important that nothing shall be done to render the crossing of the boundary more difficult than it has been in the past. However, the vast majority of us are prevented by our own limitations from rising out of the the sphere into which we have been born, and it is accordingly both legitimate and advisable to fix educational methods on this assumption. The reporters suggest accordingly that pupils in the elementary schools should at 12 years of age be transferred to a "Junior technical school." By this they mean not a trade school, but a school in which every subject is taught in reference to its relation to the boys' future calling. At the Shoreditch Technical Institute, for instance, where many

pupils pass into the cabinet-making trade, geography is taught by calling attention to the regions from which the different varieties of timber are obtained and the routes by which they are brought into this country, a method which is both interesting to the pupils and truly educational. Only one-third of the week is given to practical work, the remainder being divided equally between scientific and so-called culture studies.

At the age of 15 it is suggested the youth should enter works as an apprentice, but that during the earlier years of this apprenticeship he should have eight hours class work per week, preferably during ordinary working hours. The instruction here given should, it is held, include economic subjects.

In this connection, however, considerable difficulties will, we think, be met with, though few will dispute the great desirability of a wider knowledge of this subject, not merely amongst our working classes, but also much higher up in the social scale. The difficulty is, however, to find adequately equipped teachers. The economics of the schools and of the popular Press deals almost wholly with questions concerning the distribution of wealth and little, if at all, with the much more fundamental problem of the creation of wealth. If the latter be checked or prevented, as by Mr. Chamberlain's ill-advised electric lighting Acts and the various tramways Acts, there is so much the less wealth to distribute, and the community as a whole loses heavily, not merely directly but also by the concomitant strengthening of the industrial position in rival manufacturing communities where wiser councils may have prevailed. Telephone enterprise in this country was similarly burdened by foolish legislation and to our lasting detriment. Unless the proposed courses in economics are to take a much wider view of the subject than has hitherto been customary they may well do more harm than good.

The authors of the report we are dealing with suggest that during the course in the Junior Technical School opportunity should be taken to pick out the boys of special ability and to pass them on with scholarships to the University with a view to their becoming highly-trained engineers. The suggestion is a good one, but it will need very liberal endowments and, of course, will be of advantage only to those who mature early. Indeed, the problem of helping those who develop later is one of such exceeding difficulty as to be practically insoluble.

For the second class of students who intended from the start to be engineers as opposed to mechanics, it is suggested that 18 should be the usual age for leaving school, during the last years at which they should have acquired the knowledge of elementary mathematics and physics which has now too frequently to be picked up after actually entering the University. The latter, it is suggested, should never give a degree in Engineering until after students have had an adequate practical training in works.

In this connection it is fair to ask what is to become of the great increase in technically trained men which will result from the scheme proposed. Lord Haldane in his speech last week proceeded on the assumption that an immediate and great increase in the supply of scientifically-trained chemists and engineers would find employment forthwith. Up to the outbreak of hostilities, however, the supply was at least adequate to the demand, and, in fact many after taking an expensive course at a leading technical school have drifted into other careers. Unless the directors of industries can be persuaded of the advisability of a great increase in what the accountant calls unproductive expenditure, no career will be open for more than a small fraction of any greatly increased annual output of trained men.

For our own part we believe that the only way in which our enormous war debt can be satisfactorily liquidated will be by a very large increase in the "thinking" departments of our industries. In the past this has commonly been starved, largely, no doubt, on account of the low average return on the capital invested in our industries. Experimenting is always expensive and only a small fraction of such new departures as are attempted can be expected to succeed. When shareholders are receiving a satisfactory dividend an expenditure on even an unsuccessful experiment will be regarded leniently, but should dividends be low when failure is announced the directors are likely to have a very unpleasant experience at the annual general meeting. The result is that matters move in a vicious circle. The absence of a department specially entrusted with the development of new ideas prevents the reaping of pioneering rates of profit, and the absence of the latter tends still further to reduce expenditure under "non-productive" heads.

Dr. Garnett relates that when some years ago it was proposed to hold an exhibition of lettering and typography, he presented a written report in which it was stated that the result would be that the new ideas would be warmly praised by a few English craftsmen and would be pooh-poohed by the printing trade as impracticable, but would be thoroughly studied, and those considered promising, developed commercially by Germans. The actual result was, he states, exactly in accord with this prediction. Probably when the suggestions rejected, at sight, in the first instance, were returned from abroad, the very same printers would be prepared to adopt them. Had they had the enterprise to have established a department of their business specially charged with the study of new ideas, they might themselves have reaped the profits and prestige which they allowed their rivals to acquire. It is at least noteworthy that our census of production showed that, in general, the value of the output per man employed was greatest in those industries in which the proportion spent on so-called "non-productive" services was the highest.

THE LONDON TRAMWAY FINANCIAL DEFICIT.

The working of the London tramways for the year ended with March last showed a deficit of 73,795*l.*, which had to be met out of the general reserve fund. This latter is now reduced to 70,118*l.* and the estimate made by the Finance Committee of the County Council is that for the current year there will again be a deficit of 74,092*l.* On this showing there is justification for the remark by the Finance Committee: "We view with no little anxiety the probable continuation of the deficit." The apologists of the London County Council tramway system have much that is reasonable to say in extenuation of the circumstances, but the undertaking must be viewed and the results analysed on sound commercial principles. In other words, the Highways Committee responsible for the operation of the tramways can only be regarded from the same standpoint as an independent company operating the tramways. The Committee have the great advantage of borrowing money at a low rate of interest, because behind it there is the security of the rates, and in return for this it is naturally to be expected that the ratepayers may derive some advantage from their security being pledged. The law demands that in addition to the payment of the interest on the money a certain proportion must be allowed annually for the redemption of the loan; during the past year the total of these two items was 752,384*l.*, while the net debt outstanding at March last, less the sinking fund in hand and less 120,216*l.* in respect of the value of the surplus land, was 9,580,991*l.* An easy calculation thus shows that the interest and redemption charge is about 7¾ per cent. A private company, in addition to paying the interest on the money sunk in the undertaking, ought on financial grounds to lay aside a considerable amount for depreciation, so that the apologist who seeks to show that the deficit is explained away by the sum allowed for reduction is arguing from dangerous premises. Again, the rates on the permanent way, which last year amounted to 82,927*l.*, would be exacted from any company operating the tramways. The same applies to the proportion of money deducted from the tramways accounts for the maintenance of paving, as well as for the cost of effecting street widening, the former for last year accounting for 140,000*l.*, and the latter for 15,542*l.* Thus for rates on track and street paving and widening the tramways have had to pay 233,469*l.*, but a corresponding or greater amount would have flowed into the exchequer of the London County Council even if the tramways had been worked on the company system.

There is more of reason in the explanation that while the deficit is only 73,395*l.*, the increased cost of coal due to the war was 74,293*l.*, while 100,000*l.* was lost owing to the strike in the second month of the financial year. These charges would be equally applicable to a company system, and it is, indeed, a noteworthy commentary on the oft-repeated contention that strikes are mostly due to the capitalist that such such a heavy loss should be incurred on a municipal undertaking owing to a dispute with employees. The war conditions involved serious interference with the working of the tramways, and these, we are afraid, will continue during the present year. The payment for war service allowances to officers and employees during the past year amounted to 95,364*l.*, and it is estimated that the amount during the current year will be 122,500*l.*, according to an estimate of the Finance Committee, which was made before the introduction of the Second Military Service Bill calling to the Colours all of military age; so that in their own view this estimate may be increased. There are, therefore, full grounds for believing that the net estimated deficiency for the current year of 74,092*l.* cannot be on the sanguine side. Much is made by the Committee of the war service allowances, and it has been urged that these ought to come out of a general fund; this would be a grave departure from commercial principles. Whatever the net results may be, it is important that the accounts of any municipal undertaking should be presented so that the actual financial results should be established clearly and accurately and be comparable with those of other similar undertakings. War service allowances are being made by nearly all company undertakings, so that no unusual measure of credit is due to the Highways Committee of the County Council.

Not only will the general reserve fund be depleted this year, but a serious fact is that no payment has been made into the renewals fund since March, 1913, and it now stands at only 329,967*l.*; which, in view of the fact that the rate of redemption of the debt is slow, although in conformity with Parliamentary requirements, is a small sum, considering that the total length of the tramway system of London is over 150¼ street-miles. The renewals in recent years have varied; although nothing was added to the fund out of the revenue account, 114,987*l.* was spent in the year 1913–14, 141,813*l.* in the following year, 73,255*l.* in the year just ended, while it is estimated that 96,300*l.* will be expended during 1916–17. Another difficulty is created by the depreciation of the investments embracing the general reserve fund and others; but these, in the accounts, are continued at their cost price, whereas, as is pointed out by the Finance Committee, they have depreciated for the present to the extent of 20 per cent. If sales have to be made to meet deficiencies, this depreciation will be operative.

Full details of the working of the tramways during the past year are not available, but it is shown, in the Tramway Committee's Report to the Council on the subject, that the income for the year was 2,339,291*l.*, the receipts per car-mile being 11.42*d.*, which is low in view of the large accommodation of the cars. In Glasgow, with very much smaller cars, the receipts last year were 11.05*d.*, but in the latter instance, as we pointed out last week, there is no competition from motor-buses, electric tubes, or railways. It has been urged that the motor-buses in London get the use of the roads free. This is inaccurate. A heavy charge is made on the petrol, which is the source of power, and this is utilised for the upkeep of roads, so that the motor-bus in this way does pay for the use of the roads. The working expenses of the tramways, including the war service allowances, is 1,683,660*l.* This leaves a gross surplus on working of 655,630*l.*, from which the tramways have been unable to pay the debt charges, namely, interest and redemption, which, according to Parliamentary requirements, amounted, as already stated, to 752,384*l.* The total number of passengers carried during the year was 545,423,397. In Glasgow, with a population of about one-fifth that of London, the number of

passengers was 362,371,464. The number of car-miles run in London was 47,879,675; in Glasgow nearly 25,000,000. Thus it is clear that the Glasgow people use the cars to a much greater extent than the London people, who have the advantage of the motor-bus and the tube and other electric railways. There has been a decrease in the car-mileage in London, due to shortage of staff, war conditions, and the tramway strike, while the number of passengers increased by 5,000,000, or 1 per cent. It is recorded that the average length of the workmen's car service route is over 5 miles, the longest being 9½ miles and the shortest 2 miles, and on all routes the fare is a 1*d.* single and 2*d.* return.

The Highways Committee have been greatly handicapped, owing to the war, in carrying into execution steps for the improvement of the undertaking. There is no doubt that much remains to be done towards linking up and consolidating the undertaking, and also towards ensuring that passengers can be carried by the tramways to their desired destination. This, unfortunately, is difficult in London, because the extension of tramways into the great shopping and business areas is physically impracticable. There are greater prospects of reducing the deficit from the improvement of the power plant. It will be remembered that the Council authorised the substitution of four 8,000-kw. turbo-generators for four 3,500-kw. reciprocating engines and generators at the Greenwich power station. To begin with, there was difficulty regarding the effect on the Royal Observatory at Greenwich. The first of the new generators was delivered in May, 1914, the second in May of this year. The third is delayed owing to war work, and the ordering of the fourth has had to be deferred until after the war. It is important also that the tramway system has been linked up with another source of electrical supply, so as to provide against complete stoppage in the tramway service in the event of a failure at Greenwich. The introduction of trailers on all the car routes south of the River Thames must also tend to improve the working results, at the same time enabling the Council to cope more adequately with the periods of busy traffic morning and evening; 120 trailers are now in service, and more are under order. The system of return fares tends also to increase the traffic. A return ticket for a double 2*d.* stage fare is obtainable for 3*d.*, and for a double 3*d.* stage fare for 5*d.*, while transfer tickets are obtainable on many routes. It has also been decided to issue a 6*d.* ticket available for any four journeys on the day of issue, but this has not been carried into effect yet. The number of women employed as conductors is 1,150. As is pointed out by the Chairman of the Highways Committee, the conditions at present are abnormal, but, as we have contended, the facts must be measured on true commercial principles, and every effort be made to make the tramway undertakings of London a true commercial success.

NOTES.

Inflammability of Methane-Air Mixtures.

The redetermination of the inflammability of mixtures of methane and air by Messrs. G. A. Burrell and G. G. Oberfell (Technical Paper 119, United States Bureau of Mines) at the Pittsburg Experiment Station has its chief interest in its bearing upon mine explosions. The experiments were made in Hempel pipettes, in vessels of 2800 cub. cm. capacity, in a box, 1 ft. sq., 5¾ ft. long, and in a vertical iron pipe, 7 ft. high, 1 ft. diameter, ignited from the bottom or top by sparks between platinum wires or the flash produced by pulling apart two copper wires carrying currents of 7 amperes at 220 volts. The lower and upper limits of inflammability varied somewhat with the experimental conditions, and they differed a little from some previous observations. But the natural gas used was not pure, containing 98.8 per cent. of methane, nitrogen, and a trace of carbon dioxide, and the variations have no importance. The lower limit found was 5.5; that is to say, to propagate an explosion air must contain at least 5.5 per cent. of CH_4; this figure refers particularly to horizontal propagation, which is probably normal for mines; explosion waves travel upward more readily than downward. The upper limit fluctuated more strongly, between 12.4 and 15 per cent. Even this large discrepancy is of little practical weight, however, considering that such rich mixtures will rarely accumulate, and that the distribution of methane in a mine is anything but uniform. The paper in question gives some interesting figures on this point. When the methane escapes from the roof of a road down in the mine, it is not likely to spread so much as when it is given off by the floor or sides. Pockets of gas have been known to be swept away and to cause explosions at a distant point. A mine quite safe in certain parts may be dangerous in others. This was observed, for instance, in a mine which had been sealed after a disastrous explosion and then re-opened; the average percentage of methane found in most places was quite low, but in a cavity in the roof of entry 19 and 24.6 per cent. of methane were observed. The air itself progressively becomes deteriorated, poorer in oxygen, and richer in carbon dioxide (owing to the slow oxidation of the coal) as the distance from the shaft increases. The oxygen percentage (normally 21 by volume) went down to 20 and even to 17 in some mines examined. At the working face the air is generally a little deficient in oxygen, owing to difficulties of ventilation. It had been suggested by Harger and others purposely to lower the oxygen percentage with the object of raising the lower limit of inflammability. The suggestion is not to be favoured, as we have pointed out on previous occasions, because the workers down below want all the oxygen they can get. The experiments of J. K. Clement, made on behalf of the Bureau of Mines in 1913, prove, moreover, that in an air containing 17 per cent. of oxygen the inflammability limit would only be raised by 0.2 per cent. above that for 20 per cent. of oxygen; the addition of 10 per cent. of CO_2 only raised the lower limit from 5.8 to 6.2. Such additions would, of course, be perfectly intolerable; it is quite bad enough that in one case 1 per cent. of CO_2 was found in the return air. In ventilated mines there is rarely enough variation in the oxygen and carbon dioxide percentages sensibly to affect the inflammability of methane-air mixtures, and from this point of view further researches on the explosibility of methane have no practical interest. Good ventilation is imperative for various reasons, though it may possibly prove a source of danger by reducing the methane percentage when it is too high to allow any flame to travel in it, to a lower limit, at which it becomes explosive.

Viscosity and Density of Molten Metals and Alloys.

The viscosity of liquids is generally determined by the capillary-tube method. In 1908, C. E. Fawsitt described some experiments before the Royal Society, in which he made use of an indirect method applicable at high temperatures. He caused a horizontal disc of fireclay or graphite to oscillate in its own plane when immersed in the liquid under test, and he determined the logarithmic decrement of the oscillations. He thus studied water, mercury, alcohols, fused metals and salts; as regards mercury (test range 65 to 216 deg. C.), he agreed on the whole with F. Koch, who had in 1883 investigated the range −21 to +340 deg. C. The recent experiments of Dr. M. Plüss (*Zeitschrift Anorganische Chemie*, vol. 93, pages 1 to 44) were made at Basle with the following apparatus:—A vertical glass tube opens out, in its upper portion, into a bulb and in its lower part narrows to a capillary, 20 cm. long, which is dipped into a cup containing the liquid to be dealt with. The whole is placed within a thermostat, the vapour jacket of which is charged with liquids (ether, benzene, &c., anthracene) boiling at various temperatures ranging from 35 up to 351 deg. C.; an electric furnace gave still higher temperatures. The gas surrounding the tube and coming in contact with the metal in the cup was hydrogen or carbon dioxide. The tube was joined above to an air pump, and the liquid was thus sucked up into the capillary and into the wider portion of the tube and the bulb above; it was then allowed to sink back, and the time interval was measured which the upper level of the liquid occupied in passing two marks, the one above, the other below the bulb. In the case of pure metals and with capillaries of about 0.03 mm. diameter, this interval ranged from 100 to 300 seconds; with some alloys, which were very viscous and would oxidise rapidly when the hydrogen atmosphere was not perfect, the time was only 20 or 30 seconds, because wider capillaries had to be used. In these latter cases the viscosity could not be directly calculated by Poiseuille's formula, which presumes that the initial and final velocities of the liquid thread are zero; only relative, not absolute, determinations were possible under these conditions, and Hagenbach's correction of Poiseuille's formula was applied. Experiments were first made with mercury, which gave Koch's curve when plotting viscosity against temperature, and then of tin and bismuth. The curves of these two metals were almost straight lines, but the viscosities were slightly lower than those found by Fawsitt; for equal distances from the melting point, bismuth showed a smaller temperature coefficient than tin. The alloy series examined were lead-tin, tin-bismuth, lead-antimony. It was once more confirmed that the viscosity of an alloy cannot be calculated from the law of mixtures, whilst the densities of the lead-tin and tin-bismuth alloys were practically linear functions of the composition; the densities of the specially-prepared series of alloys were determined by weighing a block of nickel within the fused alloy. All the three series exhibited a sharp depression of the viscosity, indicating minimum viscosity at the eutectic composition, though at a temperature well above the eutectic point. The tin-bismuth series further showed two viscosity maxima corresponding to the compounds $BiSn_3$ and Bi_2Sn, whose existence is assumed for other reasons as well. But the extremes in the viscosity curves did not, as already mentioned, coincide with any extremes in the density curves. After finishing his experiments, Plüss became acquainted with the similar researches of Ragnar Arpi, who used a silica tube of considerable length heated in an electric furnace. Arpi's viscosities are all lower than those of Plüss, who points out that the temperature in Arpi's furnace was probably not uniform, and that Arpi neglected to apply the Hagenbach correction to Poiseuille's formula.

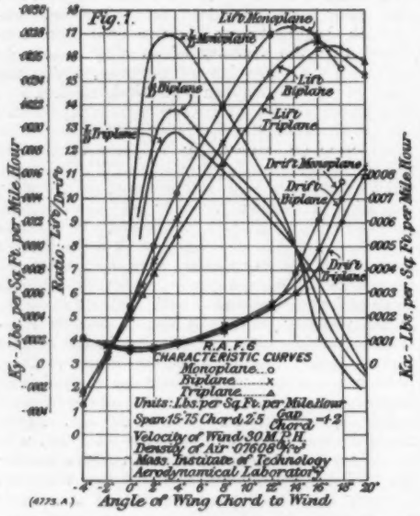
Personal.—The Chambre Syndicale des Importateurs Français de Machines-Outils, 15, Rue Fénelon, Paris, are desirous of having attention called to their new "Association of French Importers of Machine-Tools," recently constituted, according to the French law, in Paris, with a view to further develop the importation of British machine-tools in France and in Europe.

Boy Artificers in the Royal Navy.—The London County Council has been authorised by the Admiralty to nominate a number of boys for entry in January, 1917, as boy artificers in the Royal Navy, and the Council is accordingly prepared to consider applications for nominations. Conditions: (*a*) Candidates must be between the ages of 15 and 16 years on January 1, 1917, *i.e.*, their date of birth must fall either on January 2, 1901, or January 1, 1902, or between these dates. (*b*) Candidates must be the sons of British subjects. (*c*) Candidates must be in good health and of sound constitution, and be free, as far as can be ascertained, from any disease or defect that would unfit them for the duties of an artificer in the Royal Navy. Their hearing must be unimpaired, and they must possess full normal vision as determined by Snellen's tests, each eye being separately examined. (*d*) Candidates must, as a rule, be not less than 5 ft. 1 in. in height, with a chest measurement of at least 31 in. (*e*) Candidates must have attended a London secondary, central or higher grade elementary school, polytechnic, or technical institute, for at least one year. This requirement may in certain cases be waived if the candidate possesses the necessary educational attainments as a result of attendance at evening classes in higher subjects. (*f*) The parents (or guardians) of candidates must, as a rule, reside within the area of the administrative County of London. Candidates will be selected for nomination after medical examination and a personal interview. In making the selection, regard will be paid to physical fitness and health, character, diligence and intelligence in school work. The number of nominations being strictly limited, a very high standard will be required. The Admiralty expect candidates to have educational attainments at least equal to the boys who are selected by the Admiralty for similar posts by open competition. Boy artificerships offer opportunities for boys of ability to follow a useful career as engine-room artificers, and ultimately to become chief engine-room artificers (1st class) receiving 52*s.* 6*d.* a week, with the possibility of promotion to artificer engineer and engineer lieutenant. Application forms (T. 2/249) may be obtained from the Education Officer, London County Council Education Offices, Victoria Embankment, W.C., and must be returned not later than September 5, 1916.

AERODYNAMICAL PROPERTIES OF THE TRIPLANE.

By J. C. HUNSAKER, Eng. D., and T. H. HUFF, S.B.

General Problem.—The demand for increased size and weight of aeroplanes, especially sea-planes, must be met without material increase in the landing speed. On this account the wing loading remains at about 5 lb. per sq. ft., and for an aeroplane of four-fold the ordinary weight the wing area must be increased in like proportion. Monoplane construction is obviously impractical for such great spread of wings, and even the customary biplane arrangement leads to a span from tip to tip of wings of over 100 ft. The difficulty of handling and housing such a great structure has led to the consideration of wings in a tier of three, or a triplane, to provide the wing area necessary to sustain a great weight at a speed of not more than 50 miles per hour, and at the same time not unduly to extend the span.



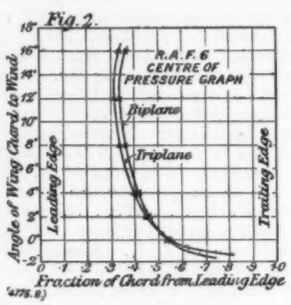
The following aerodynamical investigation was undertaken to determine the suitability of the triplane arrangement for weight-carrying as compared with the biplane. It appears that the triplane is not so effective as the biplane, and will require somewhat more power to drive; but with sufficient power the triplane can support nearly the same weight as the biplane at its attitude of maximum lift. The loss is only about 1.1 per cent. At small angles near 4 deg., for the same lift the triplane requires some 6 per cent. more power than the corresponding biplane. At 4 deg. incidence the ratio of lift to resistance is 13.8 for the biplane against 12.8 for the triplane.

Experiments on R.A.F. 6 Profile.—The experiments were conducted in the Wind Tunnel of the Massachusetts Institute of Technology, on wing models made of laminated maple scraped to a profile known as R.A.F. 6* to the nearest 0.005 in. Each aerofoil was 15.75 in. span by 2.5 in. chord, giving an aspect ratio 6.3. The models were all tested at a wind velocity of 30 miles per hour; air density, 0.07608 lb. per cub. ft.

Models were mounted vertically on a spindle, with necessary bracing in a manner described previously.† In every case the effect of the supporting apparatus has been determined by separate tests and subtracted, as well as the effect of such struts or wires as were used to ensure parallelism in the biplane or triplane combinations. The results here recorded, therefore, apply to the bare aerofoils only.

Biplane and triplane models had a constant gap between planes equal to 1.2 times the chord length, and there was no stagger or overhang.

A single aerofoil was first tested as a monoplane to serve as a standard for reference. The lift and resistance, or "drift," are expressed as lbs. per sq. ft. wing area per mile hour velocity. The coefficients found are in fair agreement with previous tests upon aerofoils of this section made both at Teddington and at this place. The precision of measurements in our wind-tunnel work is better than 1 per cent., but minor variations in workmanship of model, too slight to be detected, may lead to discrepancies of the order of about 3 per cent. between the results of tests on two apparently identical models.* The "centre of pressure," defined as the intersection of the line of action of the resultant force on the aerofoil with the plane of the chord, has been found by a graphical construction from the observed force components and the moment about the supporting spindle. In the biplane tests the centre of pressure is taken in the plane parallel to and midway between the planes of the chords of upper and lower wings, and in the triplane tests the centre of pressure is referred to the plane of the chord of the middle wing.



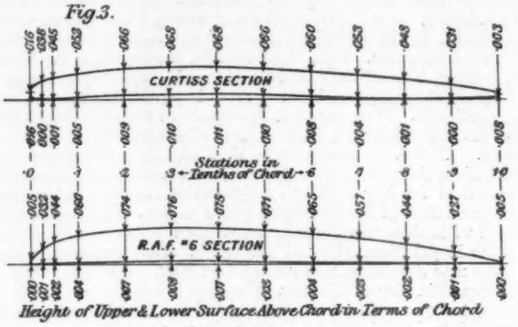
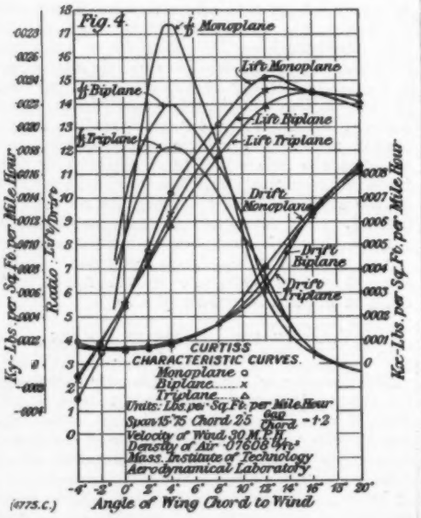


Fig. 3.
CURTISS SECTION
Stations in 1/10ths of Chord
R.A.F. "6 SECTION
Height of Upper & Lower Surface Above Chord in Terms of Chord



The curves for lift coefficient K_y and drift coefficient K_x, defined by

$$\text{Drift} = K_x S V^2$$
$$\text{Lift} = K_y S V^2$$
$$\text{(lb.)} \quad \text{(sq. ft.)} \quad \text{(miles/hour)}$$

are plotted in Fig. 1 with the angle of incidence between the chord and wind direction as abscissæ. The coefficients calculated as above from the observed forces are plotted to show the consistency of the observations.

It appears by comparison of the lift curves for the three cases that the triplane and biplane give nearly the same maximum lift at about 16 deg., but that for smaller angles of incidence the triplane lift is appreciably reduced. Confirming previous tests on biplane *versus* monoplane, we find the lift coefficient for the monoplane superior at all angles above zero. The drift coefficient for angles below 12 deg. is not greatly different in the three cases, but at very great angles of incidence, near 16 deg., the triplane has a materially lower resistance, and has a real advantage in such a "stalling" attitude.

The curves of ratio lift/drift bring out the relative effectiveness of the wings. Thus the best L/D ratio is 17 for the monoplane, 13.8 for the biplane, and 12.8 for the triplane. These values refer to small angles of attack corresponding to high flight speed. For a large angle of attack, 16 deg., the ratios are respectively 4.5, 5.6 and 6.5.

The centre-of-pressure curves are plotted for biplane and triplane in Fig. 2. It does not appear that the centre-of-pressure motion is changed in character in going from biplane to triplane. In a previous article in ENGINEERING* we showed that the centre-of-pressure motions for the monoplane and for the biplane were nearly identical. The present experiments confirm this conclusion, but the monoplane curve is omitted for the sake of keeping the figure clear.

The following table of experimental points brings out the relative values of the coefficients in the three cases, taking the monoplane coefficients as standard, and expressing those for the biplane and triplane as a percentage of them.

i.	Monoplane.		Biplane.		Triplane.	
	Actual $K_{ym.}$	Percentage $K_{ym.}$	Actual $K_{yb.}$	Percentage $K_{yb.}$	Actual $K_{yt.}$	Percentage $K_{yt.}$
0	.000486	100	.000432	88.8	.000404	83.0
2	.00103	100	.000964	93.8	.000776	75.4
4	.00145	100	.00123	85.4	.00109	75.7
8	.00218	100	.00186	85.2	.00169	77.4
12	.00278	100	.00244	87.6	.00226	81.2
16	.00277	100	.00273	98.5	.00267	96.4
	L/D	L/D	L/D	L/D	L/D	L/D
0	8.6	100	6.3	73.2	6.1	70.8
2	16.3	100	12.2	74.7	11.4	69.8
4	16.8	100	13.8	82.0	12.8	76.1
8	13.8	100	11.3	81.9	11.1	80.4
12	10.0	100	9.5	95.0	8.9	89.0
16	4.5	100	5.6	124.0	6.5	145.0

It may be noted that the drop in lift after passing the maximum is less rapid for the triplane than for the other combinations. The advantage here, if any, is of slight importance, because aeroplanes ordinarily cannot be operated at such great angles of incidence.

Experiments on Curtiss Profile.—To verify the tests just described the work was repeated for a monoplane, biplane and triplane made from an aerofoil cast in type metal, having a profile similar to that at one time employed by the Curtiss Aeroplane Company. This profile differs from the R.A.F. 6, shown in Fig. 3, by the thickness of the edges.

These Curtiss aerofoils were made of the same over-all dimensions as the R.A.F. 6, arranged, as before, with gap 1.2 times chord, and tested in an identical manner. The results for the monoplane, biplane, and triplane are shown in Fig. 4. These curves are of the same general character as those for R.A.F. 6 given in Fig. 1. We have then confirmation of the conclusions that:—

1. The maximum lift of the triplane is very nearly as great as that of the biplane;

2. At angles of incidence between 2 deg. to 12 deg. the lift and ratio L/D of the triplane are materially less than the corresponding values for the biplane.

Applied to an aeroplane, we should expect to obtain about the same landing speed on given wing area, whether the biplane or triplane arrange-

* Technical Report of the Advisory Committee for Aeronautics, 1912–13, London.

† "Stable Biplane Arrangements," ENGINEERING, January 7, 1916, page 1.

* Smithsonian Miscellaneous Collections, vol. 62, No. 4, "Characteristic Curves for Wing Section, R.A.F. 6."

* See ENGINEERING, January 7, 1916, page 1.

ment were used. The maximum speed for given engine power would, however, be less for the triplane on account of lower L/D ratio at small angles.

Interference.—Experiments were next undertaken to determine the distribution of load upon the three wings of the triplane made of aerofoils of R.A.F. 6 profile. A special apparatus was designed (Fig. 5) by which two wings of the combination could be supported independently in their proper attitude, while the remaining one was attached to the balance,

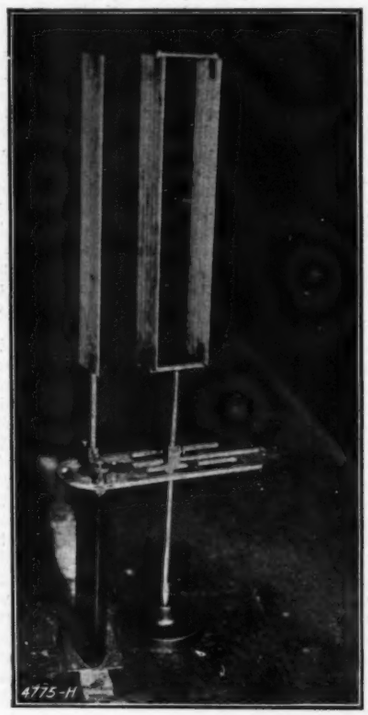
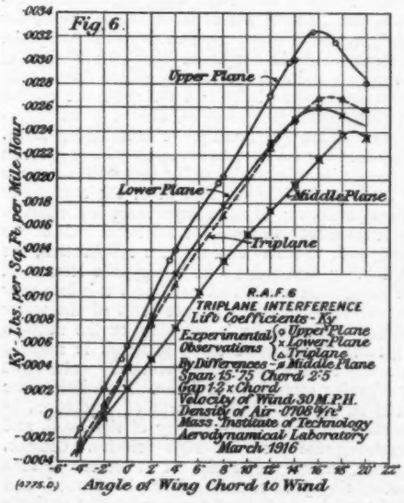


FIG. 5.

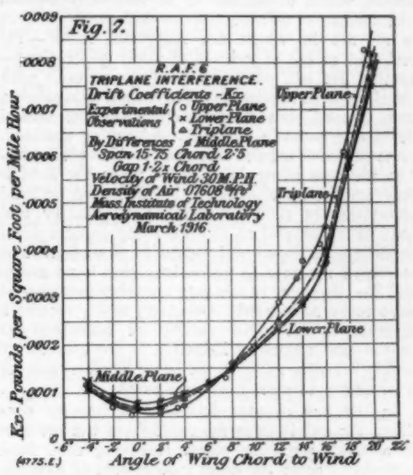


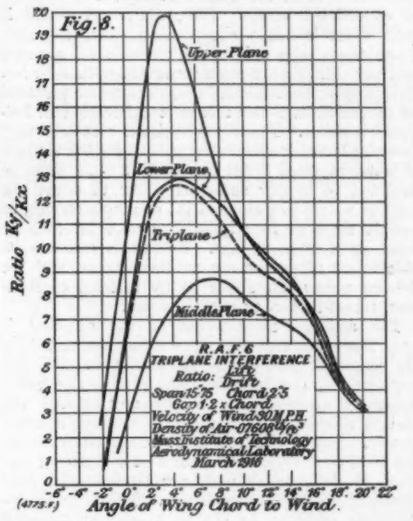
and its characteristic coefficients found by experiment. It was convenient to measure the lift and resistance components for the upper wing and for the lower wing as influenced by the others, and then to find the forces on the middle wing by subtraction from the values previously found for the complete triplane.

The results are shown by the curves of Figs. 6, 7, and 8.* It appears that the upper wing is very much the most effective of the three, and that the middle wing is the least effective. The coefficients for the lower wing are very nearly those for the three in combination as a triplane.

To estimate the lift on each wing for use in structural design of the wing girder, we give below a table showing the lift and ratio lift/drift of each wing in terms of the corresponding values for the middle wing taken as unity.

The very poor lift of the middle wing must be caused by interference with the free flow of air





due to the presence of the upper and lower wings. It would be reasonable to suppose that the middle wing influences the lower wing to the same degree that the upper wing of a biplane influences the lower wing, and that it influences the upper wing of the triplane to the same degree that the lower wing of

Angle of Incidence.	Lift Upper.	Lift Middle.	Lift Lower.	L/D Upper.	L/D Middle.	L/D Lower.
0	2.68	1.0	1.82	3.63	1.0	2.30
2	2.14	1.0	1.76	3.18	1.0	2.13
4	1.91	1.0	1.64	2.59	1.0	1.69
8	1.56	1.0	1.36	1.49	1.0	1.37
12	1.56	1.0	1.31	1.30	1.0	1.34
16	1.49	1.0	1.20	1.22	1.0	1.17

a biplane influences the upper wing of that combination. Consequently, if this reasoning hold, we should expect the sum of the observed lifts on the upper and lower wings of the triplane to be equal to the observed lift on the biplane R.A.F. 6 previously tested.

The observed biplane lift coefficient and the hypothetical biplane lift coefficient, calculated from the sum of the lifts on upper and lower wings of the triplane are plotted in Fig. 9. It appears that for all angles below the critical angle where the lift coefficient drops off, the discrepancy is slight.

For a given wing profile there is a definite angle of no lift. Our method of measuring wind direction in these experiments admits of a precision of about 0.25 deg. Since all of our curves are plotted on angle of incidence as abscissae, they may be moved bodily to right or left 0.2 deg. and still express the results within the limit of precision of the experiments. It has been found necessary to correct the lift curve for the hypothetical biplane in this manner by moving it to the right 0.25 deg. in order to give the same angle of no lift.

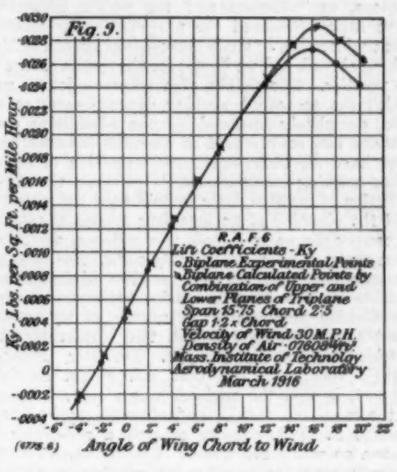


Fig. 9.
R.A.F.6
Lift Coefficients - Ky
o Biplane Experimental Points
Biplane Calculated Points by Combination of Upper and Lower Planes of Triplane
Span 15·75 Chord 2·5
Gap 1·2 x Chord
Velocity of Wind 30 M.P.H.
Density of Air ·07608 lbs.
Mass. Institute of Technology
Aerodynamical Laboratory
March 1916
Ky - Lbs. per Sq. Ft. per Mile Hour
(4775.e.) Angle of Wing Chord to Wind

The lift coefficient at 16 deg., the critical angle, is very difficult to determine with any certainty on account of the unstable nature of the fluid motion at this angle. Violent eddy-making begins here, and the balance tends to oscillate unless heavily damped. Excepting at the critical angle, the lift coefficients observed for the biplane and calculated for a similar biplane from the lift on upper and lower wings of triplane, are in such good agreement that we conclude that the curves of Fig. 9 furnish the check and verification desired.

BUILDINGS AND DEFENCE OF THE REALM REGULATIONS.—In pursuance of the powers conferred upon him by Regulation 8E of the Defence of the Realm (Consolidation) Regulations, 1914, the Minister of Munitions hereby orders as follows:—"On and after the twentieth day of July, 1916, no person shall without licence from the Minister of Munitions commence or carry on any building or construction work, that is to say, the construction, alteration, repair, decoration or demolition of buildings or the construction, reconstruction or alteration of railroads, docks, harbours, canals, embankments, bridges, tunnels, piers or other works of construction or engineering. Provided that where the total cost of the whole completed work in contemplation does not exceed the sum of 500*l.* and the use of constructional steel is not involved the licence of the Minister of Munitions shall not be required." Provisions under this Order deal with the case of Government contracts and contracts with local authorities. Persons desirous of obtaining a licence for work for which one is required should apply in writing to the General Secretary, Ministry of Munitions, 6, Whitehall Gardens, S.W.

COMMITTEE ON INTERNATIONAL TRADE RELATIONS.—The Prime Minister has appointed a Committee to consider the commercial and industrial policy to be adopted after the war, with special reference to the conclusions reached at the Economic Conference of the Allies, and to the following questions:—(*a*) What industries are essential to the future safety of the nation, and what steps should be taken to maintain or establish them; (*b*) what steps should be taken to recover home and foreign trade lost during the war, and to secure new markets; (*c*) to what extent and by what means the resources of the Empire should and can be developed; (*d*) to what extent and by what means the sources of supply within the Empire can be prevented from falling under foreign control. The Committee is composed as follows:—The Right Hon. Lord Balfour of Burleigh, K.T., G.C.M.G. (Chairman); Mr. Arthur Balfour; Mr. H. Gosling; Mr. W. A. S. Hewins, M.P.; Mr. A. H. Illingworth, M.P.; Sir J. P. Maclay, Bart.; the Right Hon. Sir A. Mond, Bart., M.P.; Mr. Arthur Pease; Mr. R. E. Prothero, M.P.; Sir Frederick H. Smith, Bart.; Mr. G. J. Wardle, M.P.; together with the following gentlemen who are presiding over Board of Trade Committees on the position of important industries after the war:—Sir H. Birchenough, K.C.M.G.; Sir A. A. Booth, Bart.; Lord Faringdon; Sir C. G. Hyde; the Hon. Sir C. A. Parsons, K.C.B., F.R.S.; Lord Rhondda; Mr. G. Scoby-Smith. Mr. Percy Ashley, of the Board of Trade, and Mr. G. C. Upcott, of the Treasury, have been appointed secretaries to the Committee.

* Lift/drift plotted from faired curves.

LITERATURE.

Irrigation Practice and Engineering. By B. A. ETCHEVERRY, Head of the Department of Irrigation, University of California. New York and London: McGraw-Hill Book Company. Vol. I.: *Use of Irrigation Water and Irrigation Practice.* [Price 8s. 4d. net.] Vol. II.: *Conveyance of Water.* [Price 15s. net.]

ENJOYING in this country a sufficiency of rainfall, with a fairly uniform distribution throughout the seasons, agriculturists and the public generally have little considered the problems of irrigation. The engineer has to study this especial branch of his calling abroad, and we do not see the results reduced to practice. The details of a scheme—details on which the successful working depends—are, as a rule, completely obscured by the admiration demanded and readily paid to the vast undertakings that have for their object the formation of huge lakes covering many thousands of acres, the construction of massive dams to hold back the waters, and the planning of an ingenious system of canals to convey the water in bulk to a distance, and in a form that can benefit the thirsty earth. But it may be suggested that the real problem of irrigation consists in producing or increasing fertility involving far-reaching problems in agriculture, in soil-treatment and water-management, that apparently lie outside engineering practice. Professor Etcheverry's view, and one that will obtain cordial support, is that the engineer who plans a system is the man who should, and often is required to, manage it. But whoever controls a complicated system on which the welfare of many small farms depends, who has to plan the schedule of distribution, give sufficiency and prevent waste, needs to be acquainted with the broad principles of agriculture. The author therefore prefaces this comprehensive work on irrigation by a volume on the use and management of water. And he is the more justified in this course that he is writing for Americans, in many parts of whose country much irrigation is local, or independent of those mammoth schemes that embrace whole counties and are superintended by an army of experts. The necessary water on a holding is frequently obtained from underground sources by pumping, or from streams easy of access, by the erection of some simple hydraulic machinery.

Some very elementary information is therefore given concerning the manner in which water circulates through the soil, the way it nourishes the plants, and the precautions that should be observed in order to secure the most favourable result on those crops that are usually grown under irrigation. It may seem a truism to assert that water is only correctly used when the losses from evaporation, percolation, and surface waste are reduced to a minimum. This, however, is the text on which much is written in the first part of the volume, and rightly, for it is necessary to emphasise this elementary truth. The losses from each cause should be largely controlled and diminished by proper methods of cultivation and distribution. Excess can be as fatal as drought; drainage is a factor of equal importance with supply, and should be kept within bounds. The neglect of these and similar simple principles has rendered vast areas temporarily infertile. When the loss and inconvenience due to inadequate supply of water have been bitterly experienced, there is always the danger, when opportunity occurs, of indulging in excess of requirement, under the mistaken belief that it is impossible to have too much of a good thing. One consequence not infrequently is that the valuable soluble salts in the soil are washed out, and the land depreciated in value. Worse, however, may befall; the injury may be made permanent if these salts are carried by water seepage, and deposited where the water comes to the surface, momentarily it may be enriching the land, but by gradual accretion producing the dreaded alkali, inflicting a lasting injury on the land. Then there is an outcry for drainage, always an expensive and sometimes a difficult operation; but to many a farmer the ideal system would be one in which water flows uninterruptedly on to the land and a similar stream flows off, forgetting the impoverishment of the land that must follow from such a wasteful method. The more correct treatment usually lies in preventing an excessive use of water; in applying it at the right time and by judicious methods.

The discussion of the proper preparation of the land to receive a water supply and of the methods of distribution over small areas forms another large section of this preliminary volume. The object of the farmer should be to construct a smooth slope, free from irregular depressions where water can collect, and from upstanding knolls, which would fail to be uniformly wetted. The formation of a continuous and small gradient is an art in which the Egyptian fellah—the recipient of the experience of many generations—excels. He will produce a marvellous result with the simplest of appliances; but American ingenuity, less tutored, has to rely on many mechanical devices to assist in grading and levelling the land, some of which are described at considerable length. The methods of applying water when the land is duly prepared are many, and will depend on local circumstances that determine the quantity and head of water, and on the prevailing topographical conditions of slope and irregularity of surface. The season of the year in which irrigation is necessary and the character of the crop are other factors that have to be considered Orchards, again, require a separate study. This variety of considerations proves that successful irrigation is not assured by simply bringing water to the land; endless resource is necessary to meet particular cases.

In the last chapter Professor Etcheverry considers the possibilities derivable from the erection of a small pumping plant, rendering each land occupier of some 160 acres independent of national or collective schemes. The main lesson taught is that water is not a cheap commodity, and may make those who enjoy, but grumble at, a moist and variable climate more contented with their lot. It is possible that rain-fed crops are not so plentiful or so varied as under intensive cultivation in irrigated districts. But the additional cost is a very material factor in estimating profits, for the amount of water required is not small. The plant must be designed to supply sufficient water to cover the land to a depth of about 2 ft., or ample enough to permit three or four irrigations of 6 in. each at intervals of 30 or 40 days. To do this various suitable forms of pumps are on the market, and the driving power can either be by internal combustion, steam-engine, or electric motor.

The author's examination of the question is very thorough, and he gives some useful tables. He considers minutely the advantages of particular installations, but it is impossible to derive exact figures, more especially as with any system the cost is relatively lower for a large than a small supply. But under the most economic working, the total cost of operation per acre will not be less than 10 dols. to 15 dols. per annum, and may certainly rise as high as 50 dols. This is no inconsiderable addition to the rent, and in England would generally be prohibitive. A comparison between these figures and those charged under the Government Reclamation Act is not easy, because in the national scheme, a building charge payable by annual instalments is made, as well as an annual rent for maintenance and operation. This latter may be as low as a dollar an acre, and generally, as might be expected in working a huge scheme, the cost to the irrigator is less than that of operating a private plant. But in any case, in arid districts, irrigation means a very heavy addition to the cost of farming, and in some cases amounts to more than the fee simple for good, well-watered land in Canada.

The larger problems of engineering that enter into a gravity system of irrigation are treated in the second volume. The "Conveyance of Water" here means conveyance of water in bulk, before distribution to a farming community. The principles enforced are illustrated by references to some of those gigantic schemes that have successfully solved the difficulties of water-carriage, and are rapidly reducing the desert tracts of the Western States. Dealing with the conveyance, Professor Etcheverry is justified in leaving on one side the subject of dam construction, whether for the development of storage or of those high masonry dams used for the diversion of water. He is not so well advised in avoiding the subject of drainage of lands, for here the importance of moving water cannot be denied, and some of the problems for supplementing natural drainage by artificial systems by way of overcoming the dangers arising from excessive seepage, water-logging, and accumulation of alkali, might have been attacked. On the other hand, the treatment of canals, or of works pertaining to them, is thorough, and though in the first place the work is written to meet the needs of teachers and students in technical schools, it will prove a valuable text-book to engineers actively engaged in the construction and operation of irrigation systems.

After an introduction discussing some features common to all schemes, such as the prevailing topographical conditions, the extent of catchment area, and the amount of precipitation expected, data on which the feasibility of any proposal rests, the author sketches a plan of a general survey and the probable cost of its execution. As indicating the nature of the operations involved, the description is sufficient, but naturally the details pertaining to survey work are not pursued, the aim being to provide a general reference to the methods of procedure peculiar to irrigation. The hydraulic formulæ that are discussed at some length are valuable, if, as we understand, the numerical coefficients are the result of experience gained in actual observations in the field. The value or the accuracy of empirical formulæ increases in direct proportion to the number of observations under like conditions, and since construction is becoming much more systematised by the adoption of definite pattern and structure in canals, flumes, &c., the elimination of uncertain factors proceeds apace with a corresponding increase in trustworthiness. The tabulation of the most recent information is of the highest importance, for the improved data, tested by frequent repetition, will be a safer guide to the engineer than the time-honoured formulæ on which he has been accustomed to rely. In calculating the flow of water in pipes and conduits there will always be a large number of variables depending on curvature, depth, variable velocity of flow, geological formations giving rise to silt, &c., that no formula will adequately represent, but concerning which a vast amount of information has been collected that needs examination.

The occurrence of silt in canals and reservoirs is of itself a large subject, though in the United States, except in the South-West, the evil is apparently less than in some places, as in India, for example, and in many systems demands no special treatment. It is suggested that the design of the main canal and the velocity of the flow should be so arranged as to permit the silt to be carried into the smaller distributaries, whence it can be discharged on the fields and prove of fertilising value. The necessary velocity, however, may be so great as to cause excessive erosion of the bed. Silt is but one of the many difficulties that beset the engineer of irrigation works; of more importance is the loss of water from seepage from the sides and beds of the canal, and, to a less extent, from evaporation, the total being summed up in conveyance losses. If the canal is in earth, and not lined, this loss may amount to some 50 or 60 per cent. of the water carried. Where water is valuable, or the demand is greater than can be easily satisfied, it may be necessary to make the canal practically water-tight by adopting some form of lining. Such linings are useful in preventing the growth of vegetation, in increasing the carrying capacity of the canal, and permitting the use of a high velocity. Cement, concrete, masonry of rocks set in cement or lime mortar, clay puddle, road oils, asphalt, wood, and sheet steel have all been employed. The author's own experiments show that an oil applied at the rate of about 3 gallons per square yard and a clay-puddle lining 3 in. or 4 in. thick are equally efficient, and stop about half the seepage. Cement mortar 1 in. thick will prevent 75 per cent. of the leakage, but to stop 95 per cent. it is necessary to have a first-class concrete lining, 3 in. thick, one part cement to two of sand and four of gravel. The porosity and texture of the soil will greatly affect the results; reliance must be placed on the experience gained in many canals, and the author's

summary of the available information will be appreciated.

The last three chapters are eminently practical, supplying a vast amount of useful data drawn from actual examples of irrigation work. The main subjects treated are the devices to be adopted in particular situations to meet difficulties arising from the presence of topographical conditions that interfere with open canal construction. It is easy to see that tunnelling may become a necessity, or considerations of economy may suggest the employment of some form of flume, or the crossing of a valley may only be possible by a pipe-line and inverted siphon. The work on irrigation systems has led to highly ingenious methods of constructing and using pipes of large diameter, and the description of the wooden stave form, as well as that of reinforced concrete, is of particular interest. The number of examples of varied construction that can now serve as guides when approximately similar conditions are encountered is very large, and the instances collected here, compared and contrasted, both from the mechanical and economical aspect, should be appreciated. The illustrations are admirable and well selected. The volumes are carefully indexed. It is announced that a third volume on "Irrigation Structures" will follow, making complete the presentation of the principles and problems that appeal to the irrigation engineer.

BOOKS RECEIVED.

The International Military Digest Annual: A Review of the Current Literature of Military Science for 1915. New York: Cumulative Digest Corporation.

United States Bureau of Mines. Bulletin No. 98: *Report of the Selby Smelter Commission.* By J. A. HOLMES, EDWARD C. FRANKLIN, and RALPH A. GOULD. Washington: Government Printing Office. [Price 1.25 dols.]

The Coming Crash of Peace and Britain's Mechanical Renaissance. By T. C. ELDER. London: Simpkin, Marshall, Hamilton, Kent and Co., Limited. [Price 2*s.* net.]

Canada Department of Mines. Bulletin No. 12: *Investigation of a Reported Discovery of Phosphate in Alberta.* By HUGH S. DE SCHMIT. Bulletin No. 13: *Description of the Laboratories of the Mines Branch of the Department of Mines, Ottawa.* Ottawa: Government Printing Bureau.

The Design of Aeroplanes. By ARTHUR W. JUDGE, A.R.C.S. London and New York: Whittaker and Co. [Price 9*s.* net.]

Annual Report of the Governor of the Panama Canal for the Fiscal Year ended June 30, 1915. Washington: Government Printing Office.

Aeronautics. First Annual Report of the National Advisory Committee for Aeronautics, 1915. Washington: Government Printing Office.

Engineering as a Career: A Book of Practical Advice to Boys and their Parents. By PERCIVAL MARSHALL and ALFRED W. MARSHALL. London: Percival Marshall and Co. [Price 6d. net.]

University of Illinois Engineering Experiment Station. Bulletin No. 84: *Tests of Reinforced-Concrete Flat Slab Structures.* By ARTHUR N. TALBOT and WILLIS A. SLATER. [Price 65 cents.] No. 85: *The Strength and Stiffness of Steel under Biaxial Loading.* By ALBERT J. BECKER. [Price 35 cents.] Urbana, Illinois: Published by the University of Illinois; European Agents: Chapman and Hall, Limited, London.

A Manual of Motor Mechanics and High Efficiency Tuning. By L. MANTELL. London: Temple Press Limited. [Price 1*s.* 6d. net.]

The Thermodynamic Properties of Ammonia. By FREDERICK G. KEYES and ROBERT B. BROWNLEE. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 4*s.* 6d. net.]

Text-Book of Mechanics. By LOUIS A. MARTIN, Jr. Vol. VI. *Thermodynamics.* New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 7*s.* 6d. net.]

Geodetic Surveying. By EDWARD R. CARY, C.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 10*s.* 6d. net.]

THE LATE DR. SILVANUS THOMPSON.—The Finsbury Technical College Old Students' Association are now engaged on the formulation of a scheme to enable all those interested to perpetuate the memory of the late Professor Silvanus P. Thompson in a suitable manner. Communications should be addressed—Mr. John E. Raworth, President of the Finsbury Technical College Old Students' Association, E.C.

OLD CLOTH TRACINGS.—Lieut. R. D. T. Jones, of the Ministry of Munitions, Department of Explosives Supplies, Storey's Gate, Westminster, asks for tracing cloth which is unused and tracings which are cancelled, for Red Cross work. The tracings are handed to a responsible person to be boiled, finally rinsed and sterilised before being used for Red Cross work.

TRADE WAR IN CHINA.

We have received from a correspondent who has just returned from China a number of notes embodying his impressions and opinions as to the course which trade is likely to take there after the war, and particularly as to the means the Germans will adopt to maintain the position they have already acquired. These notes are of special interest at the present time, and are worthy of careful consideration.

It would be well for the British manufacturer to recognise that the Paris Trade Conference can do little to assist him to capture or keep the open market abroad; and if he wishes to retain the markets that are under his sphere of influence, he must exert himself, to the utmost, to copy German methods of business, and improve on them. From reports coming from different camps where German prisoners are interned, it appears that Germany is preparing herself to make an attempt to capture the whole Chinese market; German prisoners are being taught the different dialects of the Chinese language. Germany is fully aware that Japan during the present war has attempted to oust her from her hold on this market; and it shows that her past trade with China has been greatly to her advantage, when she, even at a time when that trade is nil, retains men of military age in China to maintain her connection and keep the market open until she is again able to enter into competition.

Before the German representative of his firm in China attempts to do business there, he makes a close study of the Chinese character; he learns to understand what the term "face" means to the Chinese, and he is only too ready to recognise that "squeeze Pidgin" or "sharp," which comes under the name of "graft" in the U.S.A., has been inborn in the Chinese race through hundreds of generations. It would be incorrect to say that the only method to secure business in China is to use the graft method, but if a business firm wishes to succeed and have a fair chance of competing on all contracts, they must be prepared to recognise where the graft is necessary.

To those closely connected with Chinese matters, it is common knowledge that German merchants in China have secured sufficient contracts during the war to give them a good commercial standing immediately the war is over. These have mostly been secured by graft and sharp practice. At the beginning of the war the Germans refrained from quoting on any large contract, but lately most of the largest contracts have fallen into German hands. When the specification for any large contract is now given out they invite the head Chinese concerned to a magnificent dinner—most Chinese deals are settled over food, a point the Germans have been quick to recognise—convince them that the war will be over in a few weeks, make them a handsome present and secure their permission to insert a clause in their quotation that the material is to be supplied a certain time after the conclusion of the European War. The British firm, not knowing what has transpired, quotes price for the material to be supplied at the present time. The German this way secures good "face," as he has been able to quote lower than his competitors and has secured the goodwill of the Chinese officials by a little "cumshaw" or present, which in no way comes out of his pocket, as his price is higher than the after-war price would be.

There is one method of securing business that is a credit to the German firms, and one that the British manufacturing firms would do well to copy, working it through a combine of manufacturers. In the interior, where one would imagine there would be no business, will often be found a large building, the branch office of one of the combines of German manufacturers. There is always to be found there a first-class engineer, and one or two Chinese shroffs. The engineer, as a rule, is not a man who has been trained in one branch of engineering, but who can talk steam, electricity, oil, pumps, &c., and who spends most of his time touring round the country in his district. The usual conclusion arrived at by the British traveller who sees these places is that they are run at a dead loss. The amazing part is that they more than pay working expenses on the small orders received, the excessive percentage charged compensating them for the smallness of the order. They will receive an order for a dozen packets of needles or for an electric lighting plant with equal civility, and have them sent up from their Hongkong or Shanghai office with the utmost despatch.

The following is an instance where a British firm benefited from the enterprise of one of the German engineers in a branch office in Yunnan Province. A certain mine there had a great deal of trouble with their water supply; the German heard of it and spent some time examining the country round about. He then went up to the mine owner and said, "You have water trouble at this mine?" "Yes." "You will buy a new plant if I can give you plenty of water?" "I must get water soon or I will have to close my mine." "I can get all the water you want by pumping it from that lake 26 li. from here." "Impossible!" "I guarantee." "How much?" The deal was closed on the spot. This was just before the outbreak of hostilities, and the German afterwards was unable to get delivery of the pumps, &c. The idea had been put into the Chinese head and conditions would not allow him to await for the conclusion of the war; he therefore arranged with the British Worthington pump people to supply the plant, which ran into thousands of pounds. There was also another pumping plant to be supplied for the same province to pump 48 li.

The German supplies the idea and in many instances, as he is the only European in the district, secures the contract without competition. It is for the British syndicates now being formed to send men out to these open markets who will be able to plan out such undertakings and beat the Germans at their own game. There has been a great lack of enterprise on the part of the British merchant in China in the past, as the following will show, which happened only a few months ago. A traveller was in a certain town in Yunnan Province, and the mandarin informed him that he was forming a company to build a generating station to light up the town; he was also in the market for some mining machinery. The traveller asked a firm of Hongkong to send up a representative to go into the matter. They replied that they would do so on his depositing 100*l.* as guarantee to cover the representative's expenses. The traveller dropped the matter. Most of the electric lighting plants supplied within recent years to China—and they are not a few—have come from or through German agents. A few weeks before the specifications were given out for the generating plants for the riverside power station, Shanghai, the size, type, &c., of the machines were known to the different agents in Shanghai. The German agents immediately cabled to their works to build for stock machines to the unauthorised Shanghai specifications. When these were issued the time allowed for delivery was so short that only the German firm who had the machines in stock were able to guarantee delivery to time; they therefore secured the order.

A favourite German method to secure work at an excessive profit, especially in the interior, is to work the "extras." The British quotation for a certain electric lighting plant was approximately 2,500,000 dols. Mex., the German price 2,000,000 dols. Mex.; the Germans secured the contract; the whole amount paid to them with extras was approximately 3,800,000 dols. Mex. They had, through the good offices of some of the Chinese officials, been allowed to insert a clause that certain things in regard to the lighting would be extra, these had been included in the British quotation. Also, the Chinese company by the Germans' contract were required to retain one of the firm's engineers to be responsible for the plant for so many years at a handsome salary, the engineer to be allowed to act as the German representative for the district. This method of retaining a representative in the district is being copied to a large extent by the Japanese.

One instance may be cited that will at the same time show the untouched mineral wealth of the country. A certain British syndicate heard of a rich copper hill in Yunnan, and formed a company and purchased the concession to mine it from the Chinese Government. They employed a mining engineer in Pekin to report on the mine, and he informed them that he could see 10,000,000*l.* sterling of copper in sight. The Chinese Government heard of the report and purchased the concession back for one and a quarter millions. They then purchased a second-hand smelting plant from Japan, and the Japanese company specified in the purchase agreement that two Japanese officials would require to be retained for a certain time to look after the plant. These Japanese officials are required to report to their company all matters connected with mining, &c., likely to be of interest to them. It is only within the past few months that the Japanese secured control of the China Flour Mills, Shanghai, through an adaptation of this method.

If our Eastern Allies find it to their advantage to copy the German methods of business, the British manufacturer would be well advised not only to make a close study of these methods but to improve on them before entering on the campaign that the German trader hopes will secure for him the commercial wealth of a country whose mineral resources are undreamt of and whose millions of a population are only beginning to awaken.

In the past the British manufacturer refused to give long credit on plant supplied, and in this way he refused to take chances that the German merchant accepted with alacrity. The Germans recognised that through their long credit system they secured the contracts for goods that would otherwise never have been on the market, and that the giving of credit was sometimes of more importance than the actual price or quality of the goods.

The American manufacturer has been quick to see that in the trade war to come he is to have no place

that with his higher cost of labour competition will crush him from the market; but knowing what is coming he has not remained idle, he has planned his campaign and made his arrangements. America has a patent law in China that Britain does not possess. The manufacturer has therefore arranged to have his goods manufactured in China with cheap labour for the Eastern market; he does not hope to capture the market by this means, but he sees that it is his only chance to secure some of the wealth of the country, which he would perhaps lose through the keen competition of the rival European merchants. The head of a large firm in Boston, Mass., manufacturers of steam engines and cotton mill machinery, has just returned from China, where he has arranged with a Chinese engineering company to manufacture machinery for the Eastern market to their design, on a royalty basis, on the amount of which his company should congratulate him. The wily American is thus able to concentrate his energies on some other market and at the same time to secure as much of the almighty dollar from China as he has done in the past, as there is only a limited demand for American machinery. The British manufacturer or merchant should remember that it is useless to send a representative to the East who is not in touch with and who has not made a study of the people with whom he hopes to trade, and that every man so sent not only does not secure the best returns for his own employers, but lowers the prestige of the other British firms in the country. If the British manufacturer is prepared not only to supply first class goods but to give credit as well, and see that his representative adapts his trade methods to suit the country and those of his German competitor, he may enter the open market in the trade war to come with as much confidence as "K. of K." entered the present hostilities, but, like him, he must be prepared to leave nothing to chance. We were compelled, in self-defence, to retaliate when the German used his poison gas in the present war, and it should be a lesson to the British merchant to alter his trade methods to suit those of his German competitor, not only for his own welfare but for the trade of the British Empire. The Germans have proved themselves no mean foes in the field, and it is not likely that they will put up a sham fight in the trade war which we hope next year will see the commencement of.

THE SIR WILLIAM WHITE MEMORIAL.—The memorial to the late Sir William White, K.C.B. F.R.S., will be formally handed over to the Council of the Institution of Civil Engineers on Wednesday, the 26th inst., at 4 p.m. Subscribers to the memorial fund are cordially invited to attend at the Institution on the occasion.

DANGERS FROM RÖNTGEN RAYS.—The Röntgen Society, which recently discussed the problem of protective measures for X-ray operators and patients, has now passed a resolution, which is to be submitted to the Government. The resolution draws attention to the present conditions of X-ray examination in naval and military hospitals and to the fact that some installations are defective in their means of protection and are in the hands of inexperienced workers, who do not fully realise the attendant danger. It therefore suggests that every installation, both at home and abroad, should be inspected, and that a medical radiologist should collaborate with a physicist in this inspection. The inspectors should also advise and report on defective installations, ventilation of the X-ray rooms, aseptic conditions, &c., and collect material and keep records.

THE BRITISH CHAMBER OF COMMERCE FOR ITALY.—Mr. H. C. Elliott, of the British Chamber of Commerce, Milan, 18 Via Andegari, recently brought up the question of the great hindrance to legitimate and desirable trade between the Allies, and especially between Great Britain and Italy, due to the innumerable prohibitions issued by the respective Governments. In view of the extreme desirability of avoiding and eliminating all restrictions of which the necessity has not been fully proved, the following was unanimously adopted:—"The Council of the British Chamber of Commerce for Italy (Inc.), seeing the efforts now being made to develop commerce between Great Britain and Italy; greatly impressed by the discontent created in commercial circles by the hindrances of all sorts that are rendering more and more difficult trade between the Allies; whilst fully realising the difficulties of the present moment and the necessity of extraordinary measures to safeguard the interests of each country, especially with regard to national defence and food supplies, nevertheless consider that it would be opportune:—(1) To limit as far as possible among the Allies: (*a*) the formalities; (*b*) the number of products prohibited to be exported not interfering with national defence and food, &c. (2) To abolish, with respect to the Allies, all general restrictions concerning importation. The Council therefore express the earnest wish that the lists of goods in the export prohibition list be gone through and reduced as far as possible; that the Allied Governments agree between themselves to obtain reciprocally the requisite guarantees in order to secure the abolition of all the formalities that have hitherto had to be adopted between the Allies; and that the import prohibitions be abolished as regards the Allies."

OIL-ENGINES AND STEAM-ENGINES IN COMBINATION.*

By GEOFFREY PORTER, A.M. Inst. C.E. (President of the Association).

May I, in the first place, ask you to accept this paper with a generous allowance for the difficulties under which it has been prepared. Time has been extremely short, and though some of my friends have been most kind in furnishing a good deal of the necessary data, I should have preferred a longer time for criticism and comparison of the figures than has been at my disposal.

My object is to discuss some of the problems met with in extending a comparatively, and, in some instances, an extremely, inefficient generating station of the "lighting load" order with a plant capacity round about 1,500 kw., and equipped with steam engines, some with condensers and some without. There are dozens of such stations dotted about the country, from 12 to 20 years old, none of them with any great future so far as can be seen at present, and most of them having difficulty to make ends meet financially.

In Table I. I set out various data relating to three generating stations, "A," "B," and "C"; "A" being my own, a small one on the South Coast; "B" a London station of considerable capacity; and "C" a riverside station in the provinces. It is not proposed to elaborate an ideal situation in this paper, but to deal with established facts and to leave out of account all methods of providing additional plant except that of Diesel engines. The combination of steam and Diesel engines is now pretty well established, and reliable data are available.

Some five or six years ago several papers were read before societies of standing in the engineering world, in which were discussed the advantages to be gained by the use of the Diesel engine. Some of the writers, I think, rather overstated their claims, and all conclusions were based chiefly on results obtained on the Continent with plant manufactured by Continental firms. This was natural under the then circumstances, as few sources of information were available at the time in this country. The arguments, good as they were on the whole, fell on somewhat stony ground, for, with the Englishman's native scepticism of things foreign, engineers waited cautiously for an object lesson in their own land.

Apart from this aspect of the case it was felt rather strongly that the best coal in the world is mined in the British Islands, while a residual petroleum fuel oil (with the exception of a limited supply of shale oil) is an imported commodity; hence, with a growing demand, the price of fuel oil would rise in a greater degree than would the price of coal. Further, from a business man's point of view, the Diesel engine requires a greater capital expenditure per unit of power than does an equivalent steam plant. The question of reliability in operation arose also, though I think it was used rather as an excuse than as a genuine argument in disfavour of the Diesel engine; for engineers cheerfully bought steam turbines in the early and middle stages of their development and experienced a good deal of trouble with them, thus repeating the former experiences with electrical machinery.

Now, however, the Diesel engine is making good headway; manufacturers and users have gained experience; the fuel-oil question is in a fair way of being solved by utilising the products of the distillation of coal; and though the capital cost is and will probably continue to be high, the essence of the problem—*i.e.*, the balance in hand to credit of net revenue account in the annual balance sheet—is found to improve in proportion to the use of the Diesel engine. The mixed stations have justified the wisdom of their engineers during the present extremely difficult times; but for their efficient oil engines many of them would be in a bankrupt condition to-day.

In Table I. will be found the figures of the capital outlay on generating plant of the three stations already mentioned. The Diesel figures (capital costs) are stated in some detail, but time has not permitted the division of the steam plant costs under separate heads; they have therefore been taken as a gross total. (In my own station, "A," such sub-division has been possible, as the figures were got out for another purpose some time ago.) The items taken into consideration are engines and their dynamos, foundations, boilers, boiler settings, flues, chimney shafts, condensing plants, exhaust steam and other feed-water heaters, feed-pumps, oil-separators, and the like. Left out of account are storage batteries, boosters, balancers, and all plant outside the works, as a comparison is sought only in the generating department.

It will be seen that the capital cost per kilowatt is high. This is due not only to the higher cost of plant at the beginning of the century, and even earlier, than in more recent years, but also to the piecemeal way in which generating plant has been added to from time to time. The engineer has always been over-weighted with the bulk of annual payments of interest and principal, and was compelled to arrange them in such a manner that the annual increments of such charges did not grow too disproportionately to the annual increments of income, which he could estimate fairly closely. The result has been the pursuit of a rather hand-to-mouth policy. When making extensions it would have been preferable, in the long run, to put down additional plant sufficient to supply the requirements of 10 years or so, from the ultimate financial point of view. However desirous one may be of taking and adopting long views, circumstances are often too strong for us. The progress of an electric lighting undertaking lies along a straight and narrow way.

* Paper read before the Diesel-Engine Users' Association on Friday, June 23, 1916.

The capital expenditure on the three stations up to the time when Diesel engines were put down was (for generating plant only) as follows, viz.:—

Station "A"	29.1*l.*	per kilowatt.
" "B"	28.0*l.*	"
" "C"	39.8*l.*	"

Stations "A" and "C" condense the exhaust steam; Station "B" is a non-condensing station.

As the result of this large outlay the over-all thermal efficiency of the three steam plants in the year prior to the adoption of Diesel engines was:—

Station "A"	4.93 per cent.
" "B"	6.1 "
" "C"	2.6 "

These results are not very encouraging when one considers the money that has been put into the plant in each case. Nevertheless the figures are typical in stations of their class.

This thermal efficiency is arrived at by calculating the British thermal units equivalent to the units generated at the dynamo terminals (taking 3,412 B.T.U. per B.O.T. unit) and working out the total as a percentage of the British thermal units in the quantity of coal consumed. The figures given are not absolutely accurate owing to the heat values of the coals used not being certain, but I do not think they are very far wrong.

As one can speak most fully from one's own experience, I trust I may be forgiven if I analyse the various figures tabulated for Station "A." In 1911 extensions of plant became imperative; what had been done in the past and the possibilities of the future were very carefully considered. The capital expenditure on generating plant up to the end of the financial year 1910–11 was as under:—

Engine-Room Plant.

Engines, dynamos and foundations	4,690*l.*	15.2*l.* per kw.
Condensing plant and pipework	3,500*l.*	

Boiler-House Plant.

Boilers and their brick settings (nominal evaporation, 36,000 lb. per hour)	3,602*l.*	13.9*l.* per kw.
Feed pump, injectors and pipework	1,500*l.*	
Chimney, economiser and flues	2,400*l.*	
Gross capital expenditure ...	29.1*l.* per kw.	

On this outlay the annual charges for interest and redemption of capital amounted to approximately 1,200*l.*, or 2.23*l.* per kilowatt installed.

On the other side of the account 1 kw. of maximum load on feeders produced (in 1910–11) 1,243 units, equivalent to about 21*l.* Hence the capital charges on the steam-raising and using plant alone absorbed as much as 10 per cent. of the earnings. (Annual load factor 14.2 per cent.) Table II., line 18, page 70, shows these figures. All the figures (except fuel figures) for 1915–16 are abnormal owing to the various restrictions in force due to the state of war in which we find ourselves. The same remark would apply in a less degree to those of 1914–15.

After very careful consideration it was decided to extend the plant with Diesel engines. At the time an addition of 250 kw. was required. I decided to divide this capacity between two engines: firstly, because a better "running plant" load factor could be obtained in this way; and secondly, from motives of caution. The type of engine was new to the staff, and I argued that it would be very unlikely for both engines to collapse at the same time should they prove unreliable in operation. I am glad to say that my caution turned out to be superfluous. Better and more consistent running could not be desired.

Station "B" has provided me with figures relating to the hours lost through defects in the year 1914–15, as follow:—

No. 1 engine ...	12 hours ...	piston trouble.
No. 2 engine ...	12 hours ...	high-pressure cooling coil worn.
No. 3 engine ...	36 hours ...	compressor trouble.

The capital cost of the extension worked out at 16.95*l.* per kilowatt. Two years later a third engine was obtained coupled to a 260-kw. dynamo at a capital cost of 19.27*l.* per kilowatt. In all, a capital expenditure of 18.13*l.* per kilowatt for 510 kw. capacity.

If you turn again to Table I. you will see that Station "B" spent 26.7*l.* per kilowatt for 600 kw.; and Station "C" a sum of 18.66*l.* per kilowatt for 540 kw. of plant. Local circumstances entailed a very heavy expense for foundations in the case of "B," while plant was more expensive in first cost than at the time when I was in the market. "B" profited by other people's experience in the matter of "accessories" and wisely spent rather more money on them—notably on fuel-oil storage tanks. "C" adopted engines and dynamos which required large foundations, with the result that the gross capital outlay was rather greater than it was in Station "A." An equivalent steam plant for "A" would have necessitated an outlay of 7,450*l.*, equivalent to 14.8*l.* per kilowatt. The annual charges for interest and repayment of principal would have been 177*l.* less for a steam plant than for a Diesel plant.

On a "running plant" load factor of 65 per cent., and with coal at about 13,000 B.T.U. per pound, I expected to produce 500 units, more or less, to a ton of coal—taking the whole steam plant into consideration. Inquiries in several quarters lead me to expect confidently that a Diesel engine under the same load factor conditions would deliver 3,200 units per ton of fuel oil of 17,500 B.T.U. per pound. Assuming a price ratio of 2½ to 1 between oil and coal (as it was approximately for "A" in 1910 to 1911), there was a large margin in the

earning capabilities of the two types of plant to cover the difference in the annual charges.

The figures shown in lines 9 and 10 in Table II. give a series of actual results for "A." The figures in lines 25 and 26 in Table I. show the actual results obtained in Stations "B" and "C" as well. The low figure in the records of "C" is accounted for by the fact that one of the pair of engines put down was a two-stroke cycle machine. All engines in "A" and "B" were vertical four-stroke-cycle engines.

So much for a direct comparison between steam and oil. The problem was, however, complicated by the existence of the original steam plant, in conjunction with which the Diesel engines would be required to work. Undoubtedly the boldest course to adopt would have been to write off a part at least of the steam equipment. This plan was considered, but, in view of the very long loan period (which had still 15 years to run), the sum required for the purpose was too great for the finances of the undertaking to bear.

Had more steam plant been added to the old, and allowing for a much shorter loan period and a higher rate of interest, the annual combined capital charges would have amounted to 1.62*l.* per kilowatt of plant. The earning powers of 1 kw. were not expected to increase.

The total capital cost would have become 22.1*l.* per kilowatt. The following returns give some important figures for "A":—

Year.	Revenue per Kilowatt of Max. Load.	Gross Profit per Kilowatt of Max. Load.	—
	£	£	
1910–11 ..	21.2	11.3	Steam plant only.
1911–12 ..	20.4	10.4	Part Diesel about two months.
1912–13 ..	19.1	11.1	Diesel plant 82.2 per cent. of output.
1913–14 ..	20.0	11.8	Diesel plant 80 per cent. of output.
1914–15 ..	27.3	14.9	Diesel plant 91.7 per cent. of output.
1915–16 ..	23.2	14.1	Diesel plant 98 per cent. of output.

In the first column the revenue per kilowatt of maximum demand on feeders was artificially increased by the fact of the maximum output falling off, during the last two periods owing to restrictings, more rapidly than did the number of units sold. In the second column the figures of gross profit were adversely affected by the steam "stand-by" charges, two boilers being kept up for the greater part of the time in case of Diesel engine failures. During the last two years in the table the boiler house was entirely shut up, except for a month or so. There is no doubt that the efficient working of the Diesel engines effected a marked increase in the gross profit per kilowatt of maximum demand on the plant. In the year 1912–13 the tendency of the gross profit had begun to counteract the downward trend of the revenue curve.

An examination of the figures quoted shows that the lower cost of operating a Diesel engine plant quickly extinguishes the higher annual charges for capital, although in the case of "A" the steam plant has an advantage of 0.33*l.* per kilowatt in respect of capital charges.

Five years ago opinions differed as to the functions of a Diesel engine in a "mixed" station. Some said "work it for all it is worth and use the steam plant for peak load and emergencies;" others said "run your steam plant all the time in order to keep down the preparation charge proportion and use your oil plant for the peaks and emergencies, when its quick-starting and high-efficiency characteristics will be of the greatest advantage." I think it is now the general practice to work the Diesel engines "for all they are worth," and to keep the steam engines in reserve. At any rate, that is my own practice. In Table II., lines 6, 7 and 8 illustrate the point fairly clearly, and may be read in conjunction with the thermal efficiencies given in line 11. Lines 12 and 13a indicate the effect of keeping boilers under steam for stand-by purposes.

In Table I. a comparison of the generating costs of the three stations before and after adopting Diesel engines is instructive.

"A" shows a reduction of 0.378d. per unit generated;

"B" shows a reduction of 0.046d. per unit generated;

"C" shows a reduction of 0.276d. per unit generated;

these figures being obtained in the face of rising fuel prices. Similarly, the over-all thermal efficiencies have improved as under:—

"A"—Thermal efficiency rose from 4.93 per cent. to 22.6 per cent.

"B"—Thermal efficiency rose from 6.1 per cent. to 10.5 per cent.

"C"—Thermal efficiency rose from 2.6 per cent. to 6.5 per cent.

These figures depend, of course, on the proportion of the units generated by oil as a percentage of the total units generated. "B," having a steam plant of five times the capacity of its oil installation, was obviously unable to make so great a reduction as was "A," where the proportion was roughly 1 to 1; and "C" 1.6 to 1. The greatest reductions are in the items fuel, wages and repairs. It should be pointed out that stations "B" and "C" include in the "wages" item the proportion of "salaries" of the engineering staff which is stated separately in line 19 of Table I. for Station "A."

I refer you at this point to Table III., which shows the cost of fuel per unit generated for station "A" at various load factors for the steam and oil sections of the plant. A pair of curves below the table shows the comparison graphically. Coal cost 18*s.* 3*d.* per ton, fuel oil was at 64*s.* per ton. The figures are taken from the ordinary weekly records and are the result of everyday running conditions. From approximately full load down to half load there is a drop of 6.3 per cent. in the steam figures; and over a corresponding series there is one of 20 per cent. in the oil figures.

A statement of some of the "vital statistics" of eight generating stations having both steam and oil plants may be of interest; it shows a general tendency towards improvement in the financial position since the Diesel engine was adopted.

Station.	Reduction in Fuel Cost per Unit Sold.	Gross Profit per Kilowatt of Max. Load before Oil Plant.	Gross Profit per Kilowatt Max. Load after adopting Oil Plant.
	d.	£	£
1	.31	11.3	14.1
2	.23	9.9	10.5
3	.20	8.8	14.3
4	.18	11.1	15.2
5	.20	3.37	6.9
6	.21	8.4	10.2
7	.11	9.8	11.5
8	.06	13.4	15.1

I regret that the figures in this table are not arranged on quite the same lines as are the figures in the other tables. In the time available I was unable to obtain the number of units generated in each case, hence the unit "sold" is here the basis of the calculation.

The Diesel engine has this important advantage over the steam equipment. If valves are leaking and adjustments are not in order, the fact becomes quickly obvious. The indications on the gauges (and there are not many of them) draw one's attention to irregularities. But a steam engine may run beautifully to the outward eye and ear although piston valves and piston rings may leak, and the valve settings may be wrong owing to eccentric strap wear; the boiler settings may be drawing many cubic feet of air into the flues; the fires may be too thick or too thin. In very many cases, provided the main steam-gauge is showing about the correct steam pressure, there is a general feeling of satisfaction with the aspect of affairs.

Personally, I managed to improve the steam costs of "A" by 20 per cent. or so by the aid of flue thermometers, draught gauges, flue-gas analysers, and graduated staffs in the boiler-feed water-tanks; but even at that the benefit was but a fraction of that gained by purchasing plant that was inherently more efficient from the thermal point of view. Putting the three things together, capital charges, running costs and gross profits, the advantage accruing from the use of the Diesel engine for installations within the limits of those indicated in this paper is manifest. The figures quoted for "A" showed the combined annual capital charges for interest and redemption to be 1.95*l.* for a mixed steam and oil plant, and 1.62*l.* for a steam plant only, the difference being one of 20 per cent. Taking the running costs for the last completed financial year, the reduction in running costs from those obtained in pre-oil days was no less than 34.4 per cent.

In concluding this section of the paper I should like to urge on all Diesel-engine users the great value of the indicator diagram as a quick and ready means of testing the condition of an engine. The "hand-drawn" cards are particularly valuable as showing the distribution of the fuel oil among the cylinders. If cards are taken and filed for reference and comparison, it is not difficult to keep an engine well up to its test results. The outlay of 10*l.* to 15*l.* on an indicator set is a small matter in

TABLE I.

Item.	Station A. 1,048 Kw. D.C. Last completed Financial Year.		Station A. 1,048 Kw. D.C. Last completed Financial Year before starting Diesel Engines.		Station B. 3,700 Kw. D.C. Last completed Financial Year.		Station B. 3,700 Kw. D.C. Last completed Financial Year before starting Diesel Engines.		Station C. 1,400 Kw. A.C. Last completed Financial Year.		Station C. 1,400 Kw. A.C. Last completed Financial Year before starting Diesel Engines.	
	£	£ Per Kw.	£	£ Per Kw.	£	£ Per Kw.	£	£ Per Kw.	£	£ Per Kw.	£	£ Per Kw.
1. Capital cost of Diesel Engines and Dynamos ..	8,301	16.28	—	—	12,300	20.5	—	—	8,450	15.35	—	—
2. " " " Foundations ..	200	.39	—	—	2,500	4.2	—	—	1,277	2.37	—	—
3. " " " Accessories ..	747	1.46	—	—	1,200	2.0	—	—	506	0.94	—	—
4. Total cost of Diesel engines	9,248	18.13	—	—	16,000	26.7	—	—	10,233	18.66	—	—
5. Total Kilowatts—Diesel Plant	510 kw.	—	—	—	600 kw.	—	—	—	540 kw.	—	—	—
6. Capital cost of Steam Plant (Engines, Boilers, Accessories, including Foundations)	15,608	29.1	15,608	29.1	87,100	28.0	87,100	28.0	34,292	39.8	34,292	39.8
7. Total Kilowatts—Steam Plant	538 kw.	—	538	—	3,100 kw	—	3,500 kw.	—	860 kw.	—	860	—
8. Capital cost per Kw. of combined Plant	—	23.9	—	—	—	27.8	—	—	—	31.8	—	—
9. Annual Insurance against Breakdown—Diesel Plant	77	.15	—	—	142	.24	—	—	—	—	—	—
10. " " " Steam Plant	58	.11	58	.11	Boiler and Steam Pipes only 103	.033	103	.033	—	—	—	—
11. Annual Capital Charges (Interest and Redemption)..	—	1.95 Per Kw.-hr Generated	—	2.23 Per Kw.-hr Generated	—	Per Kw.-hr Generated	—	Per Kw.-hr Generated	—	—	—	Per Kw.-hr Generated
12. Units Generated—Diesel Plant	591,584	—	—	—	2,429,148	—	—	—	1,127,557	—	—	—
13. " " Steam Plant	11,312	—	609,609	—	2,133,214	—	5,024,127	—	403,431	—	1,332,851	—
14. " " Total	602,896	—	609,609	—	4,562,362	—	5,024,127	—	1,530,988	—	1,332,851	—
15. Cost of Fuel per unit generated. Combined Plant..	—	296*d.*	—	570*d.*	—	.459*d.*	—	537*d.*	Oil .32 Coal 1.36	.594*d.*	—	.869*d.*
16. " Lubricating Oil, Waste Stores and Water ..	—	.106*d.*	—	.092*d.*	—	.032*d.*	—	.028*d.*	—	.075*d.*	—	.048*d.*
17. " Wages (Running Staff)	—	.130*d.*	—	.206*d.*	—	.194*d.*	—	.150*d.*	—	.204*d.*	—	.190*d.**
18. " Repairs and Maintenance of Generating Plant	—	.073*d.*	—	.105*d.*	—	.090*d.*	—	.106*d.*	—	.068*d.*	—	.060*d.*
19. " Proportion of Salaries	—	.060*d.*	—	.068*d.*	—	—	—	—	—	—	—	—
20. " Total Running Charges	—	.683*d.*	—	1.041*d.*	—	.775*d.*	—	.821*d.*	—	.941*d.*	—	1.176*d.*
21. Average Price of Fuel Oil, per ton	64*s.* 0*d.*	—	—	—	67*s.* 2*d.*	—	—	—	65*s.* 0*d.*	—	—	—
22. " " Coal, per ton	29*s.* 8*d.*	—	18*s.* 3*d.*	—	30*s.* 9*d.*	—	23*s.* 9*d.*	—	17*s.* 0*d.*	—	16*s.* 2*d.*	—
23. Units Generated by Steam Plant % of Total ..	2%	—	100%	—	47.2%	—	100%	—	26.4%	—	100%	—
24. " " Oil " " " ..	98%	—	—	—	52.8%	—	—	—	73.6%	—	—	—
25. Units Generated per ton of Coal	176	—	388	—	553	—	500	—	150	—	—	—
26. " " Oil	3,200	—	—	—	3,615	—	—	—	2,435	—	—	—
27. Thermal Efficiency $\frac{\text{B.T.U. in units Gtd.} \times 100}{\text{B.T.U. in Fuel used}}$ ..	22.6%	—	4.93%	—	Approx. 10.5%	—	Approx. 6.1%	—	Approx. 6.5%	—	Approx. 2.6%	—
28 Coal used per unit generated	12.8 lbs.	—	5.8 lbs.	—	4.05 lbs.	—	4 lbs.	—	14.9 lbs.	—	10.1 lbs.	—
29. Fuel Oil used per unit generated	0.67	—	—	—	.62	—	—	—	.92	—	—	—
30. Running Plant Load Factor—Steam	69.4%	—	66.2%	—	—	—	—	—	—	—	—	—
Oil	56.9%	—	—	—	—	—	—	—	—	—	—	—
31. Annual Load Factor	15.6%	—	14.19%	—	19.9%	—	17.7%	—	—	—	19.63%	—
32. Ratio price of Oil to price of Coal	2.14	—	—	—	2.16	—	—	—	3.82	—	—	—

* "B" and "C" include proportion of Salaries (see lines 17 and 19).

comparison with the losses that may occur if an engine is not periodically checked.

The choice of the most suitable Diesel engine to accept when confronted with a number of them is not easy. All members of this Association are now acquainted with the features which are and are not desirable in an engine. But when taking the plunge in the first instance the choice was difficult. Some engineers embraced the lowest tender with the affection frequently accorded to that interesting hybrid, others did not. Manufacturers' representatives were very kind, but exhibited a considerable admiration for the merits of their own particular variety of Diesel engine, and in this respect no other attitude could be looked for.

TABLE II.—STATION "A."

Item.	1910–11. Steam Only.	1912–13. Steam and Oil.	1913–14. Steam and Oil.	1915–16. Steam and Oil.	Estimate Steam Extension.*
1. Fuel	.570*d.*	.454*d.*	.42*d.*	.296*d.*	.46*d.*
2. Wages (Running Staff)	.206*d.*	.134*d.*	.12*d.*	.139*d.*	.20*d*
3. Lubricating Oil, Waste Stores, Water	.092*d.*	.074*d.*	.06*d.*	.106*d.*	.09*d.*
4. Repairs, Maintenance, Plant	.105*d.*	.041*d.*	.07*d.*	.073*d.*	.10*d.*
5. Proportion of Salaries	.068*d.*	.055*d.*	.05*d.*	.065*d.*	.06*d.*
6. Total Cost per Unit Generated	1.041*d.*	.758*d.*	.72*d.*	.683*d.*	.91*d.*
7. % of Total Units by Steam Plant	100	17.8	20	2	100
8. % of Total Units by Diesel Plant	—	82.2	80	98	—
9. Units per Ton of Coal	388	248	334	176	500
10. Units per Ton of Fuel Oil	—	3,350	3,180	3,200	—
11. Thermal Efficiency %	4.93	12.34	12.78	22.6	(a)6.5
12. Fuel per Unit Generated Coal	5.8 lbs.	7.9 lbs.	6.7 lbs.	12.8 lbs.	—
13. Fuel per Unit Generated Oil	—	.67 lbs.	.70 lbs.	.69 lbs.	—
13A. Fuel per Unit Generated Combined	—	1.94 lbs.	1.84 lbs.	.89 lbs.	—
14. Price of Coal per Ton (AV.)	18*s.* 3*d.*	23*s.* 6*d.*	23*s.* 0*d.*	29*s.* 8*d.*	—
15. Price of Oil Fuel per Ton (AV.)	—	69*s.* 0*d.*	80*s.* 0*d.*	64*s.* 0*d.*	—
16. Water Consumption per Unit Generated	45 lbs.	—	—	—	36 lbs.
17. Water Consumption per 1 lb. Coal	8.5 lbs.	from and	d at 212° F.		10 lbs.
18. Units Sold per Annum per Kilowatt of Maximum Load on Feeders	1,243 =22*l.*	1,270 =21*l.*	1,331 =21.8*l.*	1,363 =19.5*l.*	—
19. Running Plant Load Factor— Steam	66.2%	62.2%	56.7%	69.4%	—
Diesel	—	71.0%	66.4%	56.9%	65%
20. Annual Load Factor	14.19%	15.19%	15.30%	15.58%	—

(a) Maximum observed with Oil Plant alone: 28.73% over one week.

*NOTE.—The last column of this table is an estimate of the probable results had Steam Plant been adopted instead of Oil Plant.

The attractions of the lowest tender are, of course, almost irresistible. In my judgment the lowest tender is suspect if it be more than 5 per cent. below the average of the other tenders. Being certain that this difficulty would surely arise, I attached a schedule to my specifications in which the manufacturer filled in sundry dimensions and other particulars of the engine offered. Table IV. gives a list of such particulars for engines of two capacities and may interest you. You will notice a good many differences in corresponding items. I do not venture to lay down any rule for the guidance of anyone in this matter, but I will go so far as to say that my own preference is for (1) a low piston speed; (2) a low mean effective pressure from the full load card; and (3) a low piston and crank-pin loading. The general design of the crank-shaft and its bearings, the gudgeon pins, and the lubricating arrangements throughout, must of course, be examined also. A schedule of this sort enables one to discover a "speeded-up" engine, of which several have proved to be unfortunate speculations.

The transition from the paper stage to the practical one of operating the Diesel engine not unnaturally brought to light a number of occurrences with which engineers were not familiar. Many were trivial in their nature, others were serious. Many engineers solved their problems by means of their own skill, others grumbled and lost heart and interest. In course of time it was felt that a central body competent to collect and compile records and to act as a standardising authority to some extent was a necessity. In this way the Diesel-Engine Users' Association came into being. From a very modest and quite informal beginning this association is growing steadily, and will, I trust, one day assume a very important position in the domain of the internal-combustion engine.

I notice that, in some quarters, our association is regarded as being a species of coroner's inquest with a permanent jury. It is delicately insinuated that a number of disgruntled and disheartened individuals meet once a month to weep in company over the latest smash-up. That this view, where it is held, is a misrepresentation of our activities goes almost without saying. It is a fact that we discuss breakdowns. Of course we do; we want to learn how to avoid them in future; but their number is not large enough to prevent our attention being taken up by many other and more important matters of general interest to the industry. As a whole, I can say with confidence that we do obtain the greatest satisfaction in the working of our Diesel engines. The *ts quoque* type of retort is possibly an exhibition of bad manners, but at times it is permissible and necessary. A study of accident insurance company reports leads one to wonder if all is as well as it is said to be with our old and tried friend the steam plant.

TABLE III.—COMPARATIVE FUEL COSTS PER UNIT GENERATED ON A LOAD FACTOR BASIS, EXTRACTED FROM THE WEEKLY RECORDS—STATION "A."

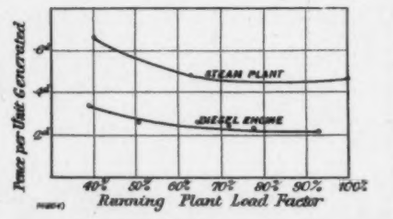
Running Plant Load Factor	% 38.9	% 40.0	% 50.1	% 62.5	% 64.5	% 70.3	% 76.8	% 91.5	% 98.0
Steam Plant	—	*d.* .625	—	*d.* .48	—	—	—	—	*d.* .45
Diesel Plant	*d.* .332	—	*d.* .260	—	*d.* .255	*d.* .223	*d.* .220	*d.* .208	—

Coal at 18*s.* 3*d.* per ton; Fuel Oil at 64*s.* per ton.

TABLE IV.—SCHEDULE OF PARTICULARS OBTAINED FROM MANUFACTURERS IN SUBMITTING TENDERS FOR DIESEL ENGINES.

Tender 1	B.H.P.	No. of Cylinders.	B.H.P. per Cylinder.	Revs. per Minute.	M.E.P. from Full Load Card.	Cylinder Diameter. (Inches.)	Length of Stroke (Inches.)	Piston Speed per Min. (Feet.)	Ratio Stroke—Bore.	Ratio of Price Accepted to Lowest Tender.
A	400	3	133⅓	187	82	20	28.4	885	1.42	1.64
B	400	4	100	175	99	18	26.0	758	1.44	1.26
C	375	3	125	200	95	18	26.0	866	1.44	1.20
D	375	3	125	200	84	20	24.0	800	1.20	1.20
E	400	4	100	175	72	17¾	24.75	721	1.40	1.18
F	400	4	100	187	72	17	25.25	786	1.48	1.18
G	400	4	100	180	92	17½	26	780	1.46	1.04
H	385.8	3	128.6	175	95	18½	28	815	1.49	1
I	400	4	100	175	95	17½	26½	773	1.51	1.04
							Av.	798.2		

Tender 2.	I.H.P.			I.H.P. per Cylinder.						
A	256	4	64	250	100	12	18.1	755	1.51	1
B	260	4	65	250	100	12	18.25	761	1.52	1.159
C	266	4	66.5	250	88.8	13½	16½	700	1.26	1.165
D	296.1	3	98.7	300	98.7	13½	16½	842	1.36	1
E	266.1	3	88.7	190	104.7	14½	22½	700	1.55	1.186
F	210	3	70	210	82	13½	18½	661	1.36	1.294
							Av.	735		



A recapitulation of all the subjects we have discussed at our meetings would be wearisome, and, indeed, impossible within the scope of this paper. I should like, however, to draw your attention to three subjects which have been of great interest and which are far from being exhausted. The first is the problem of the lubrication of Diesel engines. We collected a large amount of information and data on this subject and discovered a series of remarkable discrepancies in the course of our investigations. An endeavour to lay down any definite pronouncement in the matter of how much or how little oil should be used for various engines was found to be impossible at the time. Mr. C. O. Milton, one of our most energetic members, gave us a communication on the subject and contrived to establish some relations between the lubrication of engines and the conditions under which they are used; but even here he lighted upon two series which did not agree and for whose disagreement there did not appear to be any reason. We had hoped that Mr. G. E. Windeler would have given us some useful hints on the subject this evening, and doubtless he would have done so had he been able to read his paper on "Methods and Difficulties of Lubrication in Diesel Engines." The actual rate of the destruction of lubricating oil in the cylinder of a Diesel engine is a matter which would, I am sure, well repay a careful investigation. I trust we shall return to this subject in the not too distant future.

We are at present engaged in investigating the vagaries of air compressors. In general they work well; but occasionally they show bad habits. The committee of the association have a report on the subject in hand and hope to bring it before the association before long. There are differences of opinion among our members, and not unnaturally so—we are not a "mutual admiration society"—and the happy mean will doubtless be struck. One feature, however, emerges as being of paramount importance, and that is, the behaviour of oil-impregnated vapours under the influence of high pressures and temperatures. I think it is a line of investigation eminently suited to the labours and talents of the National Physical Laboratory. I trust that institution may be persuaded to take it up in the future. Users, manufacturers and Government officers unite in recognising the necessity for the discovery of the real properties of these vapours.

Last, and perhaps of the greatest importance, is the question of fuel-oil supplies. This is a matter of vital importance to the whole industry. The present state of war has opened our eyes in many instances to the manner in which this great and rich country has become dependent on other communities for absolute necessities. The fuel-oil question can be and will be solved by our own chemists and engineers. The matter is of more than a sectional interest; it is a national interest.

Our engines will work well on the products of the distillation of coal—British coal—that coal which is used to-day so uneconomically that at the best but 15 per cent. to 20 per cent. of its available energy value is actually utilised. Continental users and manufacturers have used tar oils and tars with the greatest success for many years in their Diesel engines, and we can do so too. The cost of adapting an existing engine for the purpose is not excessive, and under present conditions, at any rate, such cost will be abundantly repaid.

There is an opening for a new market for the by-products of gas works, blast-furnaces, gas-producers and low-temperature coal-distillers which should be well worth cultivating. When that is established we shall be, in one direction at least, an independent people. England's greatest commercial asset is her coal; her position in the trade of the world is chiefly due to this gift of the gods. It is the business of manufacturers and users of power plants in particular that it should be adequately conserved. In working our coal deposits we are indeed living on our capital; the greater the reason, then, to use it to the best advantage. With these remarks I will bring this paper to a close, and trust that the figures I have put before you have been sufficiently interesting to merit your attention.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia.—The Sydney Office of H.M. Trade Commissioner in Australia has forwarded copies of the specifications, conditions and forms of tender in connection with calls for tenders by the New South Wales Department of Public Works, Sydney, as follows:—Sealed tenders, on the proper forms, will be received by the department (1) up to 2 p.m. on August 8 for the supply and erection of pumping machinery for the Glen Innes water supply; and (2) up to 2 p.m. on August 14 for the supply of 12 pumping plants driven by oil engines, for railway water supplies.

Portugal.—With reference to the Bill to authorise the Municipality of Alenquer to construct a railway from the station of Carregado to Alenquer, it is notified that the *Diario do Governo*, Lisbon, publishes the text of a law based on the Bill referred to, and sanctioning the raising of a loan of 260,000 escudos (about 38,000*l.* at current rate of exchange), to be devoted exclusively to the construction of the line.

Brazil.—The *Diario Official*, Rio de Janeiro, publishes a Decree (No. 12,036) approving the project for the reconstruction of the section of the Theresopolis Railway between Piedade and Rair da Serra, a distance of 21,555 m. (about 13 miles). The estimated cost of the undertaking, including the provision of rolling-stock, &c., is 1,469,459 milreis (about 78,000*l.* at current rate of exchange).

THE INDUSTRIAL FUTURE OF CHINA.—At present China seems in hopeless confusion, but, according to *The London and China Telegraph*, nothing is more certain than that she will regenerate herself. It is improbable that any other Power, however ambitious and capable, will succeed in placing her in subjection. The mutual jealousies of the Powers are China's best protection. The late Lord Salisbury once said that a nation containing three or four hundred millions of the most industrious people on earth could never become moribund; and he was right. China has greater material resources than either Europe or America. She has almost inexhaustible deposits of coal and iron, still scarcely tapped. She can grow anything within her own borders, from tropical products to the crops of temperate zones. Her workmen can live on the equivalent of 1*d.* a day, and they have not lost the zeal for industry as the West is losing it. Misgovernment, and not lack of resources, is at the root of the economic stress which has caused so much ebullient discontent in China in recent years. China has passed through such phases before and emerged from them successfully, and she will do so again. Organised industry on a Western basis is still in its infancy in China; but she is learning rapidly, as Japan has already learned. Until now other countries have competed for a place in the markets of China. The time must come when the Chinese, with their own manufactured products in their hands, will be knocking at the doors of the markets of the world. When we talk of "trade after the war," let us not forget to think about China.